DOCUMENT RESUME

ED 200 450 SE 034 605

AUTHOR	Lampert, Seymour; And Others
TITLE	A Solar Energy Curriculum for Elementary Schools, Kindergarten Through Grade Six. Field Test Copy.
INSTITUTION	Department of Energy, Washington, D.C. Office of Solar Applications.
REPORT NO	DOE/CS-0128
PUB DATE	Feb 80
NOTE	349p.: Not available in hard copy due to colored pages throughout entire document which may not reproduce well.
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Curriculum Development; Elementary Education; *Elementary School Science; *Energy; Energy Conservation; *Environmental Education; Science Education; *Science Instruction; Social Studies; *Solar Radiation
IDENTIFIERS	Alternative Energy Sources

ABSTRACT

Presented is the field test version of an elementary school solar energy curriculum consisting of nearly 50 activities and demonstration experiments. Developed by a team of teachers and subject matter specialists, these materials are grouped under seven content area headings: (1) Scientific Method; (2) Energy and Life; (3) Sun and Light; (4) Energy Phenomena: Forms of Energy; (5) Energy Phenomena: Energy Measurement; (6) Energy and Society; and (7) Energy Systems and Society. Introductory background readings for teachers and/or students accompany each section. Lesson plans list the grade level, objectives, evaluation strategies, vocabulary words, and procedure. (WB)

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A Solar Energy Curriculum for Elementary Schools

Kindergarten through Grade Six

February 1980

U.S. Department of Energy

Assistant Secretary for Conservation and Solar Energy

Office of Solar Applications

Washington, D.C. 20585

SE 034 605

ACKNOWLEDGMENTS

A great deal of the creativity in this solar energy curriculum for elementary schools has come from the dedicated hard work of our teacher consultants. We owe them our compliments and our thanks. They are:

Susan S. Ballantyne
Nadine R. Barsky
Ralph W. Engh
Michael E. Harris
Phyllis Howard
Gale Y. Inadomi
Elinor de Lancey Ishagaki
Jacqueline K. Ota
J. Lynne Liebelt
Barbara C. Lingle
Constance Lue
Rita J. Patten
Lane Petersen
Virginia Salley
Ruth C. Sebring
Theressa J. Simpson
Betty H. Smith
Alan Turner
Jo Ann C. Williams
Judy Woodward
Roberta Burke

Special gratitude is also extended to others who shared their expertise with us on the project. Mr. Grant Cary's extensive background in science education enriched our work. Dr. Gordon Footman's insights into evaluation resulted in some effective usable strategies for assessing how well the students learn our solar energy material. Mr. John Lappin of Southern California Edison Company helped to stimulate our thinking with ideas from lessons that were most effective in classrooms he had visited in his educational responsibilities.

An outstanding member of our team was Mr. Joel Grishaver, a doctoral candidate in instructional technology, who provided structure to our sessions, exciting ideas for lessons, and a wealth of skills in generating appropriate materials. Students from the USC School of Engineering who contributed their strength in the basic subject matter were Don Langford, Erin Doughty, Phil Gooding, and Jose Quinones.

We are honored to have worked with such a committed, talented team of experts.

Seymour Lampert

Kathleen M. Wulf

Gilbert Yanow

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INTRODUCTION TO CURRICULUM

In view of accelerated depletion of "conventional" energy sources, there is a need to educate our society in the use and conservation of these dwindling reserves. Not only will our present lifestyles be affected, but also those of future generations. Therefore, there is a concomitant need for development and implementation of alternative energy sources, primarily of solar energy.

Since students now in elementary schools will be the sector of the world's population most directly affected by problems of energy depletion, it is appropriate immediately to provide them with programs dealing with concepts of solar energy. This project, then, aims to educate children in grades kindergarten through six toward two major goals: 1) an appreciation of the need for energy conservation, and 2) an understanding of the potential of the sun as a suitable alternative energy resource.

The lessons, demonstration experiments, and evaluation strategies for this program in solar energy were developed through a systems model of curriculum design. An interdisciplinary team of subject matter specialists, and teachers shared expertise at appropriate points in the process. All participants worked within the followed plan (Figures 1 & 2):

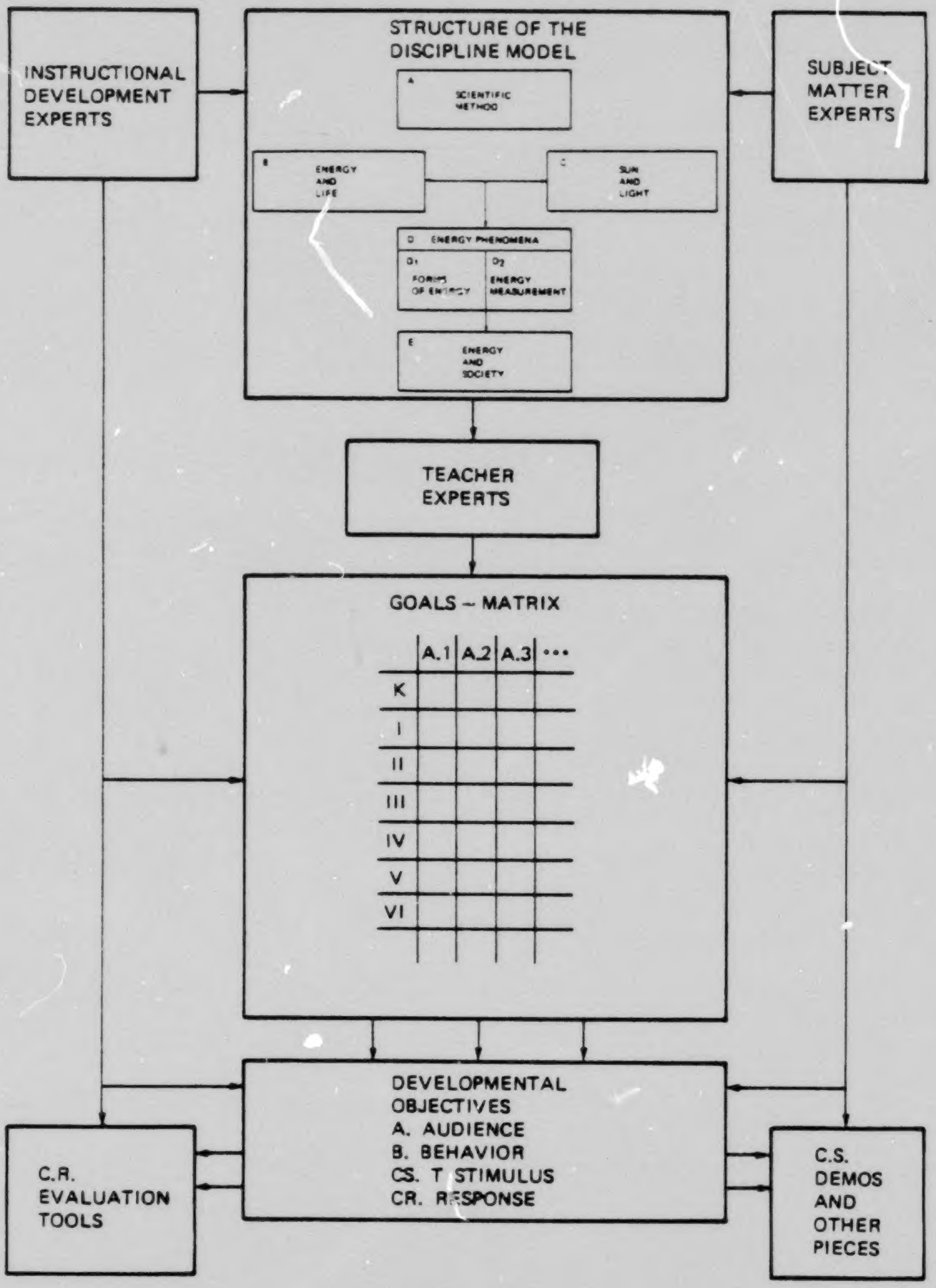
a. Identifying a structure of the discipline of solar energy.

b. Writing goals for learners.

c. Turning goals into behavioral objectives.

d. Generating appropriate lessons.

e. Deciding upon evaluation.


INSTRUCTIONAL DEVELOPMENT EXPERTS
STRUCTURE OF THE DISCIPLINE MODEL
A SCIENTIFIC METHOD
B ENERGY AND LIFE
C SUN AND LIGHT
D ENERGY PHENOMENA
D1 FORMS OF ENERGY
D2 ENERGY MEASUREMENT
E ENERGY AND SOCIETY
SUBJECT MATTER EXPERTS
TEACHER EXPERTS
GOALS – MATRIX
A.1
A.2
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•••
K
I
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III
IV
V
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A. AUDIENCE
B. BEHAVIOR
CS. T STIMULUS
CR. RESPONSE
C.R. EVALUATION TOOLS
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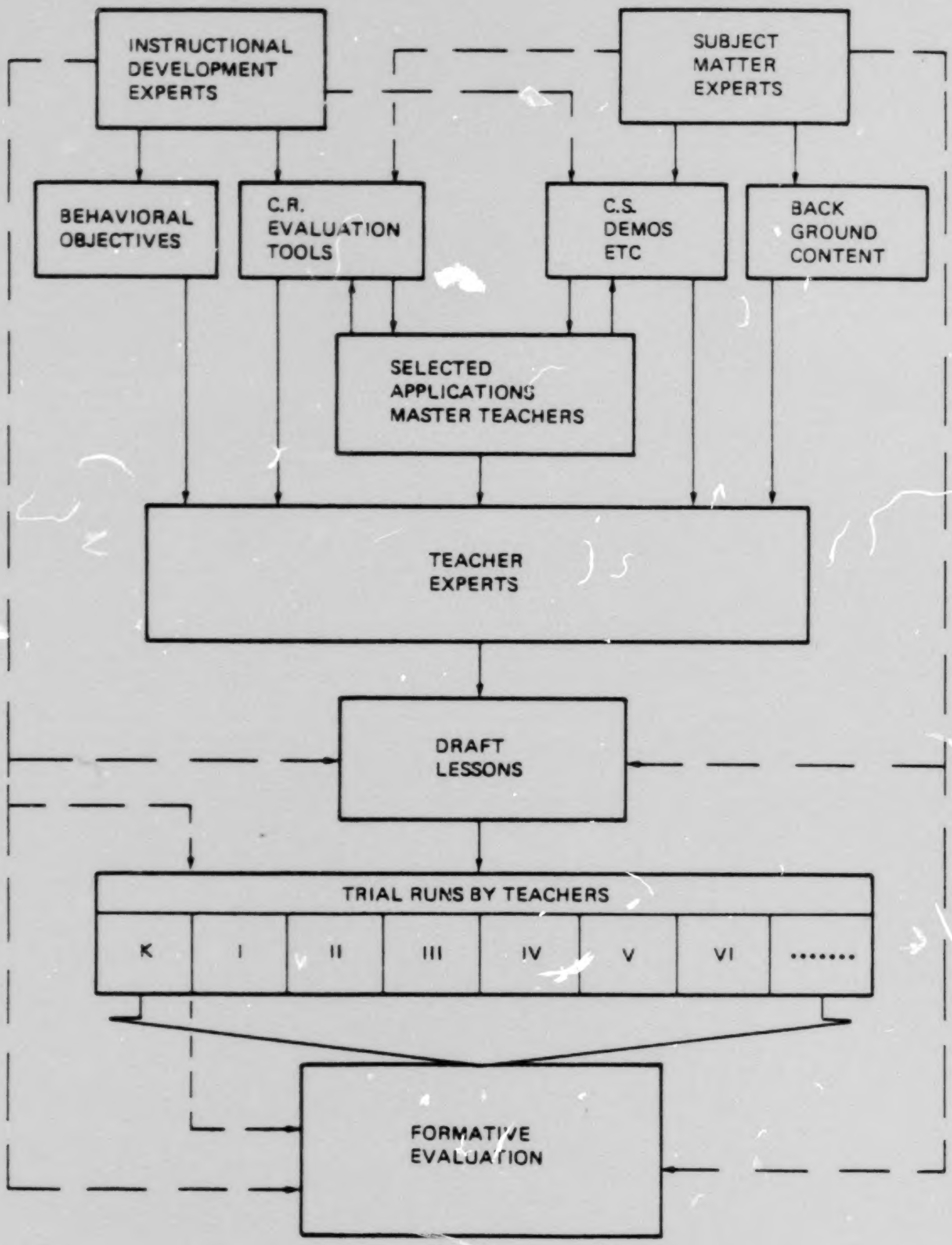
Figure 1. Development Process


INSTRUCTIONAL DEVELOPMENT EXPERTS
SUBJECT MATTER EXPERTS
BEHAVIORAL OBJECTIVES
C.R. EVALUATION TOOLS
C.S. DEMOS ETC
BACK GROUND CONTENT
SELECTED APPLICATIONS MASTER TEACHERS
TEACHER EXPERTS
DRAFT LESSONS
TRIAL RUNS BY TEACHERS
K
I
II
III
IV
V
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....
FORMATIVE EVALUATION

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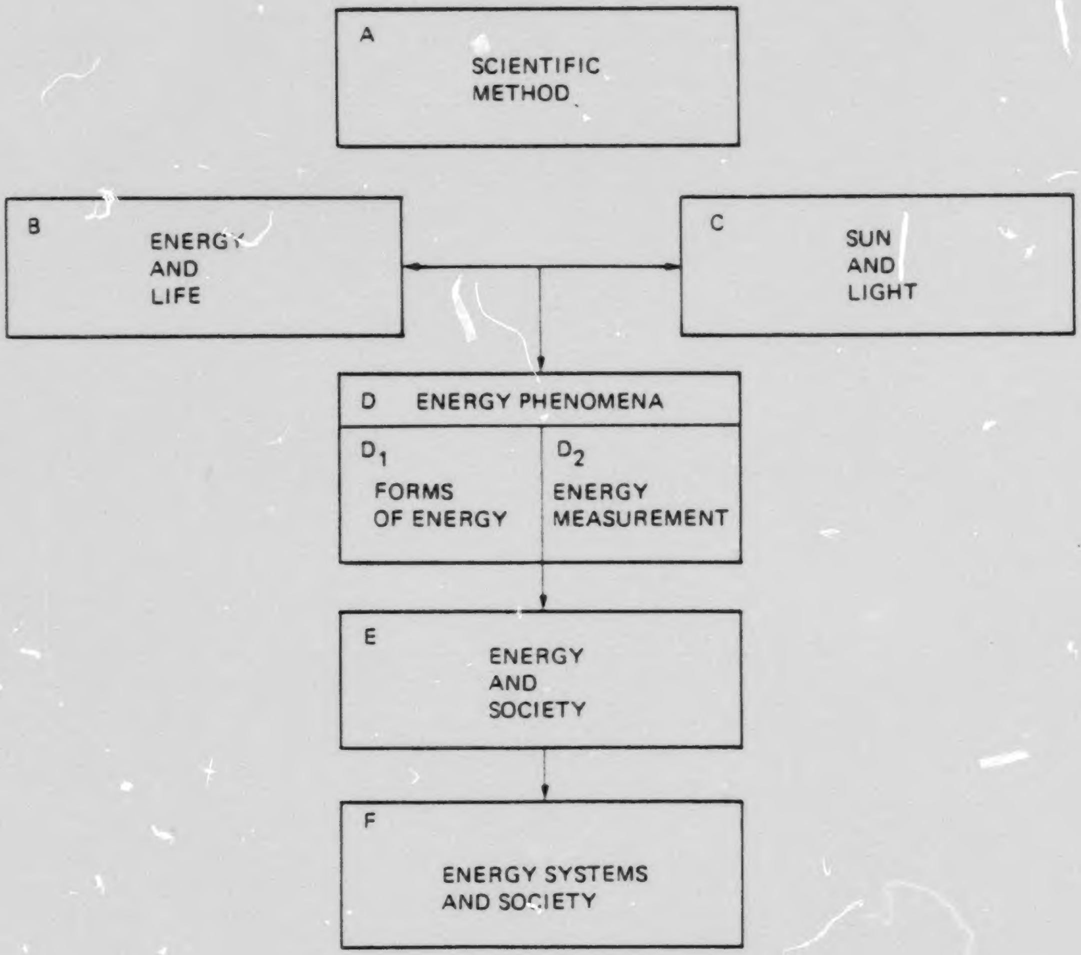
A
SCIENTIFIC METHOD
B
ENERGY AND LIFE
C
SUN AND LIGHT
D ENERGY PHENOMENA
D_1
FORMS OF ENERGY
D_2
ENERGY MEASUREMENT
E
ENERGY AND SOCIETY
F
ENERGY SYSTEMS AND SOCIETY

Figure 3. Structure of Discipline Model

1. Identifying a structure of the discipline of solar energy. Since there were no established cohesive elementary school curricular pieces for concepts of solar energy, the development team had no fixed model of exactly which content areas were to be included. While some existing science materials addressed the energy crisis in part, none moved directly from that point into the need for solar energy. It was necessary, therefore to create a "structure of the discipline" model of solar energy, incorporating essentially a content map of what the lessons would include. This model describes both the necessary background understandings (i.e. the requisite areas of the sun and of energy), the basic content areas, and some of the related socio-economic issues (Figure 3).

Using the model or content map, the subject matter experts trained the educational curriculum and teacher experts in fundamental ideas of solar energy. They presented a history of the use of the sun as an energy source, early solar devices, and possibilities for future use. With such a background, the team was ready for the next step in the process; establishing goals.

2. Writing goals for students. Unlike the previous task of creating a structure, goal writing was not new to the education experts. The subject matter experts received training in proper stating of goals using work of Bloom (1956), Gronlund (1972), and Mager (1967). Basing their work on the assumption that the structure of the discipline of solar energy was representative of the concepts students needed to learn, the team generated goal statements from each category, e.g. the sun. Table 1 (Goal Statements) illustrates how the process reflects the concept category, marked by letters, and how goals from that category are labelled

Table 1. Goal Statements

A	1.	Students grow in their ability to apply the scientific method.
B	1.	The students understand that the sun is essential to all life on earth.
	2.	The students learn the physical properties of the sun.
	3.	The students learn the astronomical relationships of the sun to the earth.
	4.	The students learn that all of our sources of energy on earth are traceable to the sun.
C	1.	The students learn to recognize various forms of energy.
	2.	The students evolve a concept of "energy."
	3.	The students understand the difference between renewable and non-renewable energy sources. (Clean/renewable is desirable and environmentally sound.)
	4.	The students learn about energy measurements.
	5.	The students understand how the present "energy crisis" is a crisis in the way we use energy.
	6.	The students know about alternative energy sources.
	7.	The students understand energy conservation.
D	1.	The students understand the basic problems involved in utilizing solar energy.
	2.	The students learn some of the ways of using solar energy. (Passive/action-Direct/Indirect) (Matrix)
	3.	The students understand some of the technical problems involved in utilizing solar energy: Collection (and non-collection-passive) conversion, utilization, storage.
E	1.	That the students will be able to recognize how political issues affect solar energy technology.
	2.	That the students will understand how economic issues affect solar energy.
	3.	That the students will understand the environmental impact of solar energy.
	4.	That the students will understand the sociological constraints on using solar energy.
	5.	That the students will understand the institutional constraints on using solar energy.

in numerical order. Category "A", included in the structure of the discipline model, emerged as an "enabling goal", one that was required to help achieve the other goals.

3. Turning goals into behavioral objectives. After goals had been established, a development matrix was formed showing goals by letter and number for each grade level (Figure 4). Teachers, curriculum experts, and subject matter experts worked in writing teams, tackling objectives on the matrix in clusters, e.g. one team was assigned responsibility for all "A" objectives from all categories for one grade level. Continuity through grades was thereby enhanced. It will be noted that the coding used indicates the Objectives A thru E, the first subscript refers to the appropriate subcategory, while the second subscript refers to the appropriate grade level K thru VI. As the lessons were tested at various schools in Southern California, the ordering of the goals/objectives were revised to reflect these findings. The Discipline Model in Figure 3, shows the principal areas for which the lessons are presented and coded accordingly.

A four-part format for objectives was employed, (Figure 5).

A. Audience — The students (grade, age, entry level).

B. Behavior — (identifies, comprehends, applies, analyzes, synthesizes, evaluates).

CS. Conditions of the Stimulus (after watching, reading, participating).

CR. Conditions of Response

GOAL / GRADE	A	B	C	D		E
K	A_K	B_K	C_K	$(D_1)_K$	$(D_2)_K$	
I	A_I	B_I	C_I	$(D_1)_I$	(D	
II	A_{II}	B_{II}	C_{II}	$(D_1)_{II}$		
III	A_{III}	B_{III}	C_{III}			
IV	A_{IV}	B_{IV}	C_{IV}			
V	A_V	B_V	C_V			
VI	A_{VI}	B_{VI}	C_{VI}			

Figure 4. Development Matrix-Goal Statement for Each Grade Level

A	AUDIENCE	(WHO)
B	BEHAVIOR	(LEARNS TO DO WHAT)
C_S	CONDITIONS OF THE STIMULUS	(PROCESSING WITH WHAT)
C_R	CONDITIONS OF THE RESPONSE	(DEMONSTRATED BY DOING)

Figure 5. Development Objectives

4. Generating appropriate lessons. Again writing in teams, lessons were designed to facilitate growth toward meeting the objectives defined above. With the four-part statement of the objective available, writing lessons became a task of simply "fleshing out" or "building upon" the basic statement. Frequently it meant developing a work sheet or a response device for the learners. Lessons retain their codes letters for category of content and numbers for independent lessons in that area.

5. Deciding upon Evaluation. The culmination of this systems approach to curriculum development was to provide the teacher some assessment tools. Consequently each lesson recommends an appropriate criterion referenced evaluation phase. With young students in early grades care has been taken to provide evaluation schemes which are not predicated upon the ability to read, e.g. to indicate by coloring a worksheet (in the lesson) that the student has "read" a thermometer correctly. Similarly, these lessons allow for continuous progress. For example, if a kindergarten class masters all of the "C" (energy) lessons for kindergarten level they can move directly to the first grade lessons in category "C" for greater depth. Grade level labels are not intended to be restrictive.

Teachers using these curricular pieces, therefore, can be assured that they were developed systematically by an interdisciplinary team. We, the authors, encourage the creative teacher to use our lessons, our teacher concept write ups and our demonstration devices to go beyond what we have already produced for this short course in solar energy. At this point there are possibilities for adapting more lessons from these basic ones, providing more instructional activities, and "customizing" these lessons for use with special students. It is our hope that; 1) we will help you and your students achieve your goal of a deeper understanding of solar energy, and that, 2) you will share your critical ideas and recommendations with us.

Since we value teachers' comments concerning the lessons used with students, three short forms (Figure 6, 7, and 8) are included for your evaluations. We will be grateful to you if you will share your ideas with us. We will apply any useful suggestions to the final version of the curriculum.

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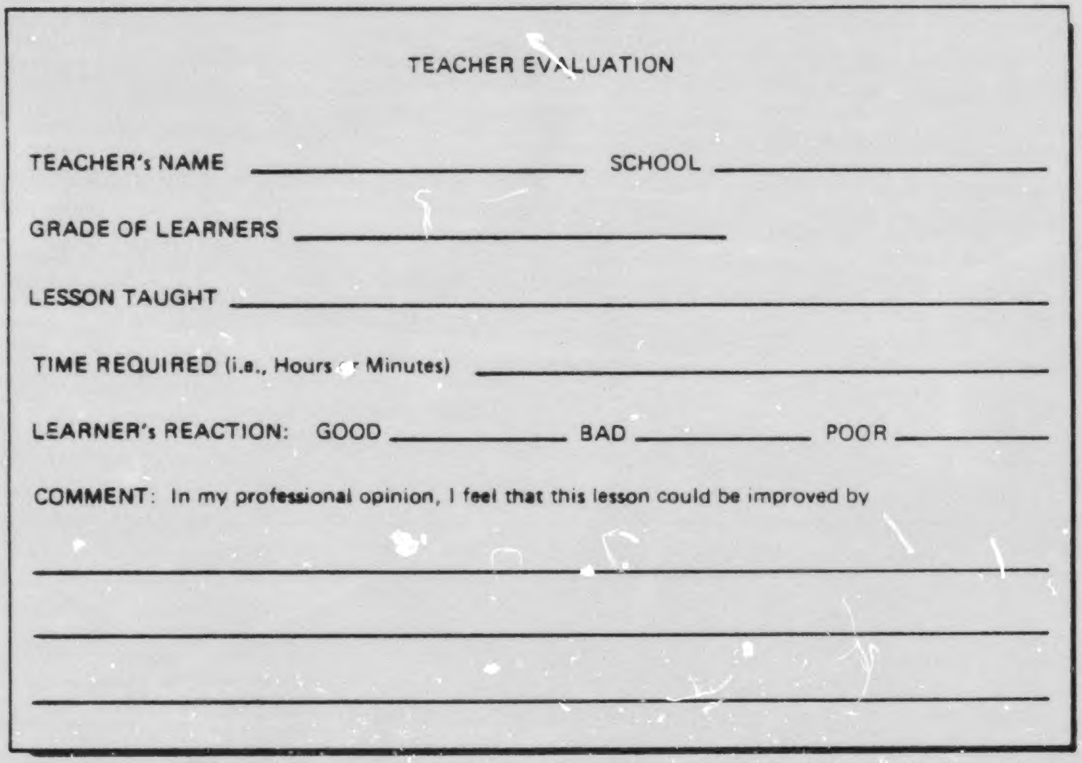


TEACHER EVALUATION

TEACHER's NAME ______________ SCHOOL ______________

GRADE OF LEARNERS ______________

LESSON TAUGHT ______________

TIME REQUIRED (i.e., Hours or Minutes) ______________

LEARNER's REACTION: GOOD ________ BAD ________ POOR ________

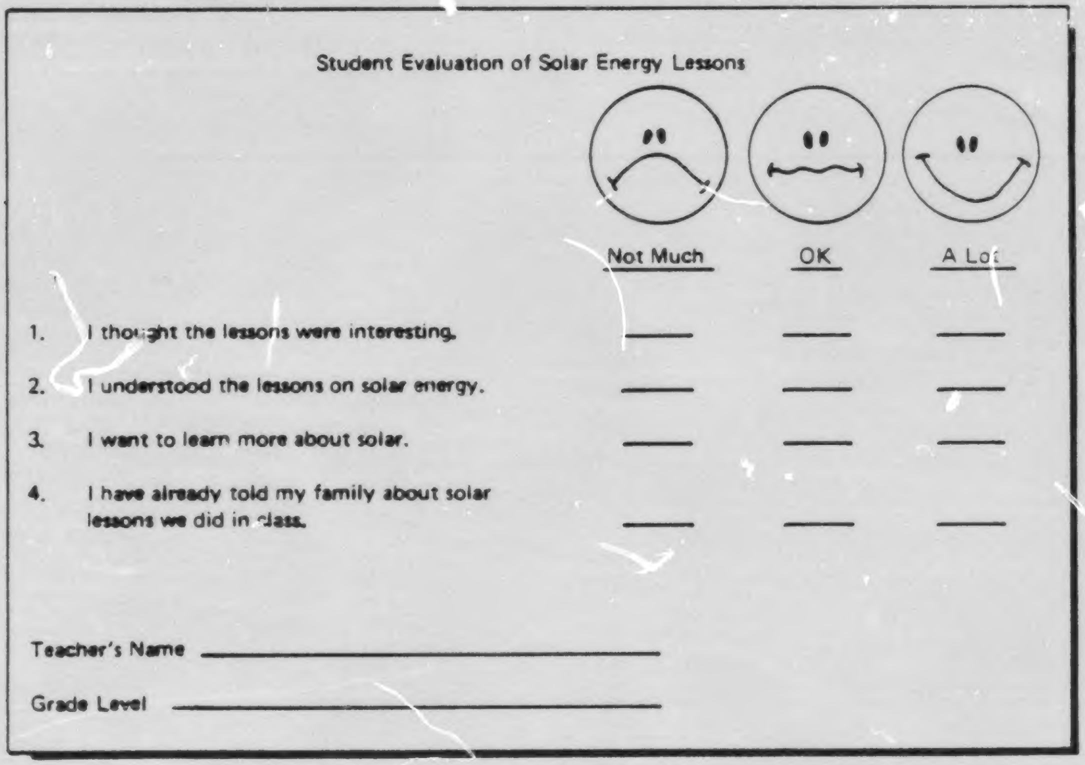
COMMENT: In my professional opinion, I feel that this lesson could be improved by

____

____

____

Figure 6. Sample Charts for Teacher Evaluations



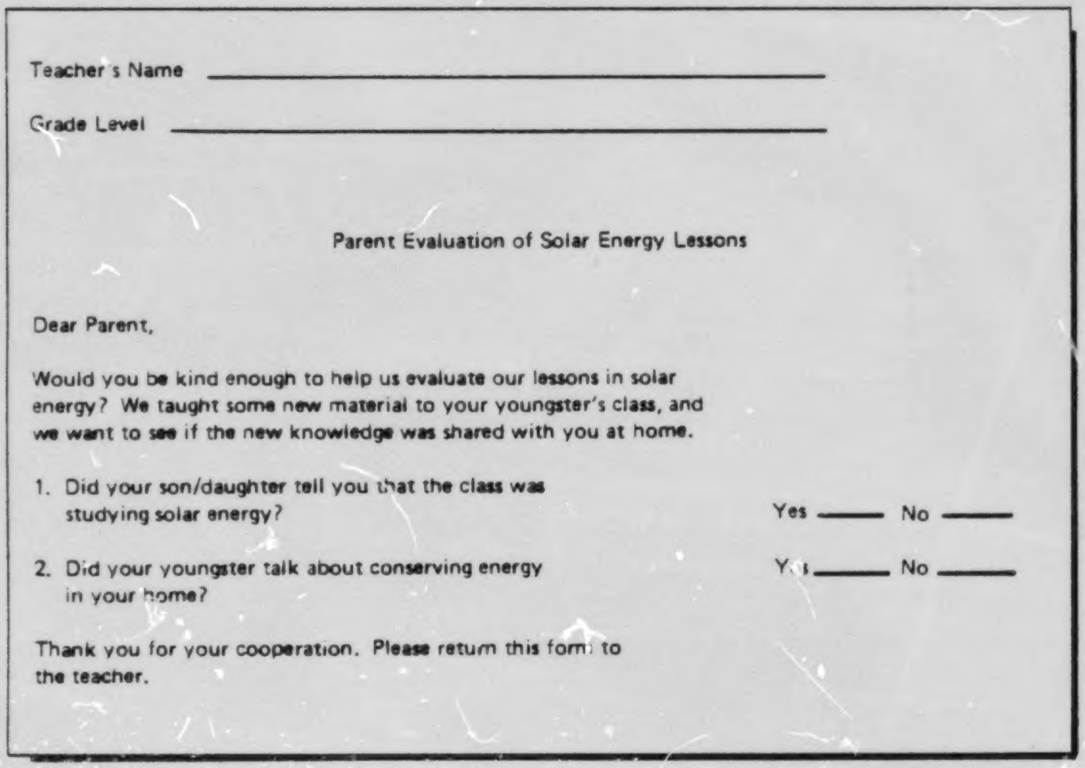
Student Evaluation of Solar Energy Lessons

		Not Much	OK	A Lot
1.	I thought the lessons were interesting.	____	____	____
2.	I understood the lessons on solar energy.	____	____	____
3.	I want to learn more about solar.	____	____	____
4.	I have already told my family about solar lessons we did in class.	____	____	____

Teacher's Name ______________

Grade Level ______________

Figure 7. Sample Chart for Student Evaluations



Teacher's Name ______________________________

Grade Level ______________________________

Parent Evaluation of Solar Energy Lessons

Dear Parent,

Would you be kind enough to help us evaluate our lessons in solar energy? We taught some new material to your youngster's class, and we want to see if the new knowledge was shared with you at home.

1. Did your son/daughter tell you that the class was studying solar energy? Yes ____ No ____
2. Did your youngster talk about conserving energy in your home? Yes ____ No ____

Thank you for your cooperation. Please return this form to the teacher.

Figure 8. Sample Charts for Parent Evaluations

LESSON PLAN

The ensuing sections are suggested Lesson Plans which are identified by both Grade Level and Content Materials.

The principal areas, as shown in Figure 4 are defined by capital letters A thru E as given in Goals Statements (Table 1) namely:

A	Scientific Method
B	Energy and Life
C	Sun and Light
D_1	Forms of Energy
D_2	Energy Measurement
E	Energy-Society-Applications

The coding system uses the arabic numerals to indicate the sub-sections of the objectives categories. The second identifying symbol is K for Kindergarten level or Roman numeral I thru VI for appropriate grade levels. (Note: Only Category D has two parts D_1, D_2).

Each set of lessons in a particular objective category, are preceded by resource materials for the teacher's information or as appropriate for students' reading. The student reading materials are identified as "4th - 6th Student Reader."

It is the teacher's preprogative to select those lessons appropriate to the particular class, that is if it is an advanced class you may opt to use lessons and materials of the next level or conversely start at a lower level if class is not as advanced. All materials in each objective category are grouped together for this purpose so that the program K - VI may be examined in toto by the user of the curriculum.

It should be noted that in Series A identified as the Scientific Approach, lessons have been provided for K thru III.

After the third grade the stepwise approach involving the Scientific Method will have been established. In the later grades it is suggested that the teacher review the introductory materials provided and apply the Problem, Prediction Experiment (Observation) and Conclusion (PPEC) as appropriate and applicable in Sections B thru F.

Further Section F has been provided as an addendum to the original scope, it goes into detail, as to the use of Solar Energy Systems. These sets of lessons and the attendant reading materials have been prepared for grades IV thru VI. However, the reading material in Section F contains information on solar systems that may be useful background material for teachers of all grade levels.

In Figure 9, we have provided a representative Participants Observation Sheet that you may find useful.

All Figures called out in the various lesson sections have been repeated and included in Appendix A "Applications and Demonstration Materials."

20

NAMES		PARTICIPATION				NON-PARTICIPATION			
		EYE CONTACT	VERBAL INTERACTION	PHYSICAL INTERACTION	MOVEMENT TOWARDS	EYE CONTACT	VERBAL DISTRACTION	PHYSICAL DISTRACTION	MOVEMENT AWAY
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
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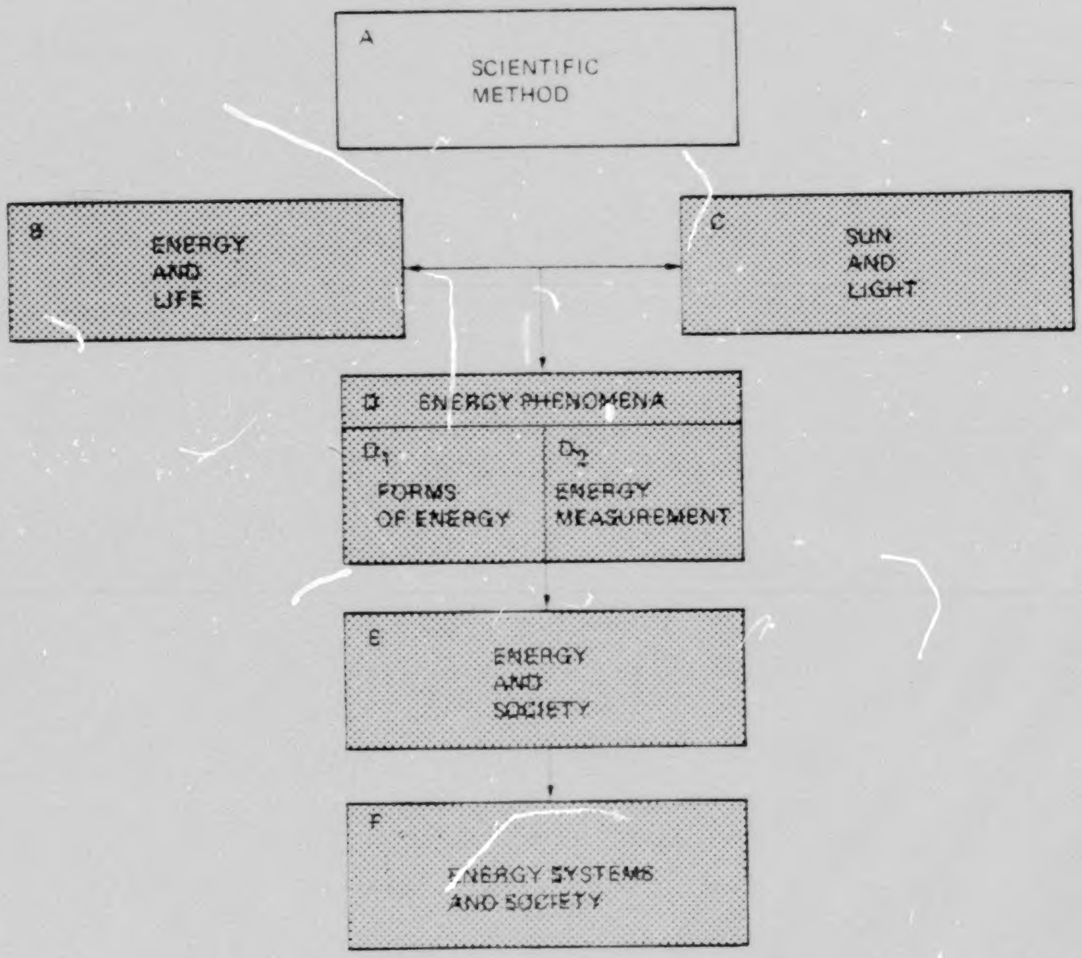
30									

Figure 9. Suggested Participation Observation Sheet


A
SCIENTIFIC METHOD
B
ENERGY AND LIFE
C
SUN AND LIGHT
D ENERGY PHENOMENA
D_1
FORMS OF ENERGY
D_2
ENERGY MEASUREMENT
E
ENERGY AND SOCIETY
F
ENERGY SYSTEMS AND SOCIETY

A – SCIENTIFIC METHOD

RESOURCE MATERIALS

When reading a book of science, it is often assumed[1]* that all statements concerning knowledge are true and correct. Suppose the book of science is not convincing, then some method of investigation is needed to find out if this book of science contains truth or falsehoods. Of course, it is not a good idea to assume the book entirely false since it may take some time to investigate everything it contains. A method of investigation that may be more convincing than words, may be through experimental observations[2]. In order to reduce the possibilities of falsehoods that may affect observations, a precise method of experimentation must be involved. This is the scientific method. The scientific method is necessary not only to convince ourselves of the truthfulness of some assumed fact or statement, but to convince others of its validity[3]. Widespread experimentation and agreement of facts may be organized into a theory[4]. One such application of the scientific method is outlined below.

a. Problem

To acquire some knowledge concerning the truth or validity of a statement. Questions must be asked that may be answered by investigation. Examples of questions asked are:

What makes the statement true?
What kind of experiment can be performed to show this?
Can it be shown that the statement is false?

There will be the cases where questions asked are answered and unasked questions are answered.

---

*Note superscript relates to words whose definitions are contained in the Glossary page.

b. Hypothesis[5]

A hypothesis is a prediction that may be proved or disproved by observable evidence. Any hypothesis that has been found untrue must be restated or discarded. A confirmed hypothesis is one that can be repeated and observed by a large number of people. An example of a hypothesis may be the statement, "the sun will rise tomorrow". The observation can be repeated and may be observed by a large number of people. A hypothesis is not an absolute truth since it may be possible that the sun will not rise tomorrow (although highly unlikely). Many hypotheses, as in this case, may be proposed from past experiences such as the sun has risen each day. A hypothesis is also subject to restrictions such as the sun rises for an observer on earth, but it may not for an observer in space. (i.e., space traveler)

c. Materials

Materials are sensory[6] or mechanical[7] devices that may be used for observational purposes. As in the sun's rising, one must have the means of an eye (sensory device) to observe it. Material selection is subject to accuracy needed. An example may be in measuring temperature. A rough idea of the temperature of a beaker of water may be sensed from touch, either hot or cold. A more accurate measurement of temperature may be sensed by placing a thermometer (a mechanical device) in the beaker. In this case, temperature is sensed visually.

d. Procedures

Procedure is the step by step method of obtaining desired effects. Such as in the case of the beaker of water. In order to produce a hot sense, the beaker is heated, or to produce a cold sense, ice cubes may be placed in the beaker.

e. Observation

An observation is a sensory perception of some phenomena[8] that have taken place. They can be described or communicated to others verbally, by written expression (including mathematics), or by drawings. Any one or all of these communication devices may provide an accurate description of an observation.

f. Conclusion

The conclusion is an agreement as to whether the hypothesis tested is correct or incorrect. If the hypothesis is incorrect as observations may provide evidence, then it must be corrected or improved. Questions that have been asked may be answered and other questions may be raised. Observations that have not been previously hypothesized may be included.

Remember this is only application of the scientific method. Other methods that follow a logical pattern may also be acceptable.

GLOSSARY

1.	Assume	To accept a statement true without proof or demonstration.
2.	Observation	A physical property that can be measured directly, such as weight and temperature, and can be noticed with one of five basic senses - hearing, sight, smell, taste, and touch.
3.	Validity	Justifiably based on truth or facts that are sound and supportable by observational or demonstrational means.
4.	Theory	Knowledge applicable in a relatively wide variety of circumstances distinguished from experiment or practice.
5.	Hypothesis	An assumption subject to proof by demonstration or experimental means.
6.	Sensory	To become aware of or perceive by any one of the animal functions of senses.
7.	Mechanical	Process whereby a machine or tool aids in interpreting phenomena.
8.	Phenomena	Occurrences or facts directly perceptible by the senses.

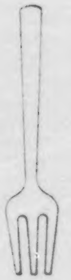
THE SCIENTIFIC METHOD

STUDENT READER (4th - 6th)

How often have we asked ourselves questions like "How does that work", or "Why is it doing that?", or even "Why do you feel that way?". It is one thing to ask these questions, but it is another thing to actually try and answer them. This thing we call "The Scientific Method" is just a logical procedure that one can employ to find answers to questions asked, in an orderly repeatable manner.

Do you have to be a trained scientist or a genius to use "the scientific method"? The answer is emphatically no. The scientific method is basically an approach for observing and thinking about things, much the same as following a recipe for baking a cake. In this case, instead of coming out with a chocolate layer masterpiece, one comes out with more knowledge about how things work in nature or in many cases, the way people do things.

When baking a cake there are certain items or tools one works with, such as measuring spoons, the cup, a cookbook, the mixer, and so forth. When working with the scientific method, we have some similar tools — they may not be tools you can hold in your hand, but in this case, they simply are words or methods that are used. Let's look at some of these and take a sample problem and apply the scientific method to it. The first thing we must have is "a problem". This problem may be a question someone poses to us, or may be something we are looking at and thinking about. For instance, let's imagine that we have just come from a distant country. We have landed at a strange location and we find on a table a strange looking device. (See the picture at the right). We notice this device has something like a shaft or handle on it, about six to seven inches long, and on the end of the handle are three sharp pointed prongs sticking out. The question is what is this strange looking item?



Now, we use our next tool called a "hypothesis." What is a hypothesis? A hypothesis is just the initial conclusion we may come to by looking at the item and thinking about it. We can handle the device, push our fingers on the end, observe it in any way that we wish, and based on our thoughts about it, and our initial observations, we can come up with one or several hypotheses about what we might use this strange item for. After observing it, we have come up with two possible hypotheses:

a. It may be some kind of comb to use on your head.

b. It may be some item for spearing things. (We thought about the possibility of it being a back scratcher, but very quickly we decided the handle was too short for this use and eliminated this possibility.

Now the question is, how do we determine which one of these hypotheses might be the correct one? To accomplish this, we have an "experimental procedure" to investigate in a logical manner the use of this device. In relation to the first hypothesis, the idea of it being some kind of a comb, we will do the following experiments: 1) We will use it on our head; 2) We will see how easily we can hold the device when we comb the opposite side of our head from the hand we are holding this device in; 3) We may even enlist the aid of someone with a heavy mustache to see how well this device will work in the process of combing the hairs under the nose. That will be one set of experiments. We will do another set of experiments using this strange device to try and retrieve items. We will do experiments such as 1) Trying to stick this device into a piece of wood; 2) We will tie a string on the shaft part and try throwing the device like a harpoon, and lastly, 3) We will hold the device in our hand and try using it on soft materials such as a piece of meat or small items of food on a plate.

Now we retire to our scientific laboratory to carry out these experiments. Without going into great detail, we will tell you the results that were obtained. In relation to the first set of experiments, we found that the sharp points of this strange device scratched our head; we found that the device was difficult to hold when we tried to comb the other side of our head, and lastly, we found when attempting to comb a mustache, this strange device would get caught in our nostrils and cause excruciating pain. In relation to the second set of experiments, it was found that the strange device was very difficult to poke into a piece of wood; when we threw the device, it did not go through the air well or stick into things very well; however, we found it was an excellent tool for eating meat or other items off the plate. Therefore, based on these experimental programs, and comparing the results with our hypothesis, we determine this device is best suited to be used to skewer small pieces of food and to be used as an aid in eating. We have decided to call the device a "spoon". (Even in the best scientific investigations, many times we make some small error in judgement).

Let us stop for a moment and review the points we have tried to make. The scientific method is simply a way of looking at nature; a logical step by step approach to try and understand a little better the world around us.

THE PPEC METHOD

To use the scientific method, we generally will do the following sequence of operations:

a. We will first define the problem.

b. After some thought, reading, talking to people, or any other method of preliminary investigation, we will determine a number of possible hypotheses or predictions that could be the solution to our problem.

c. We will invent an experiment or series of experiments that will enable us to either prove or disprove our hypothesis

d. We will compare the results of our experiments with our initial hypothesis and make conclusions about the solution of our problem.

NOTE: Sometimes the results of our experiments may be inconclusive and we will have to go back to step (2) and start again.

In the use of the scientific method in the primary grade level, we will normally work with one hypothesis. The students will be required to first determine what the problem is, they will then make a prediction or guess what they think the outcome will be, i.e., they will determine their own hypothesis, they will observe what happens, experiment, compare what happens with their predictions to see if they were right or wrong conclusions.* You use the scientific method in dealing with people also. You can think about what people do and what they say and hypothesize under what conditions they might do or say something else. You can then put together a little questionnaire or a small little skit and see what the students do. This will be the scientific method applied to social problems rather than physical science problems. Enjoy using the scientific method.

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*This approach may be described by its parts, i.e., the PPEC System (Ef. Figure Problem Prediction Experiment and Conclusions)

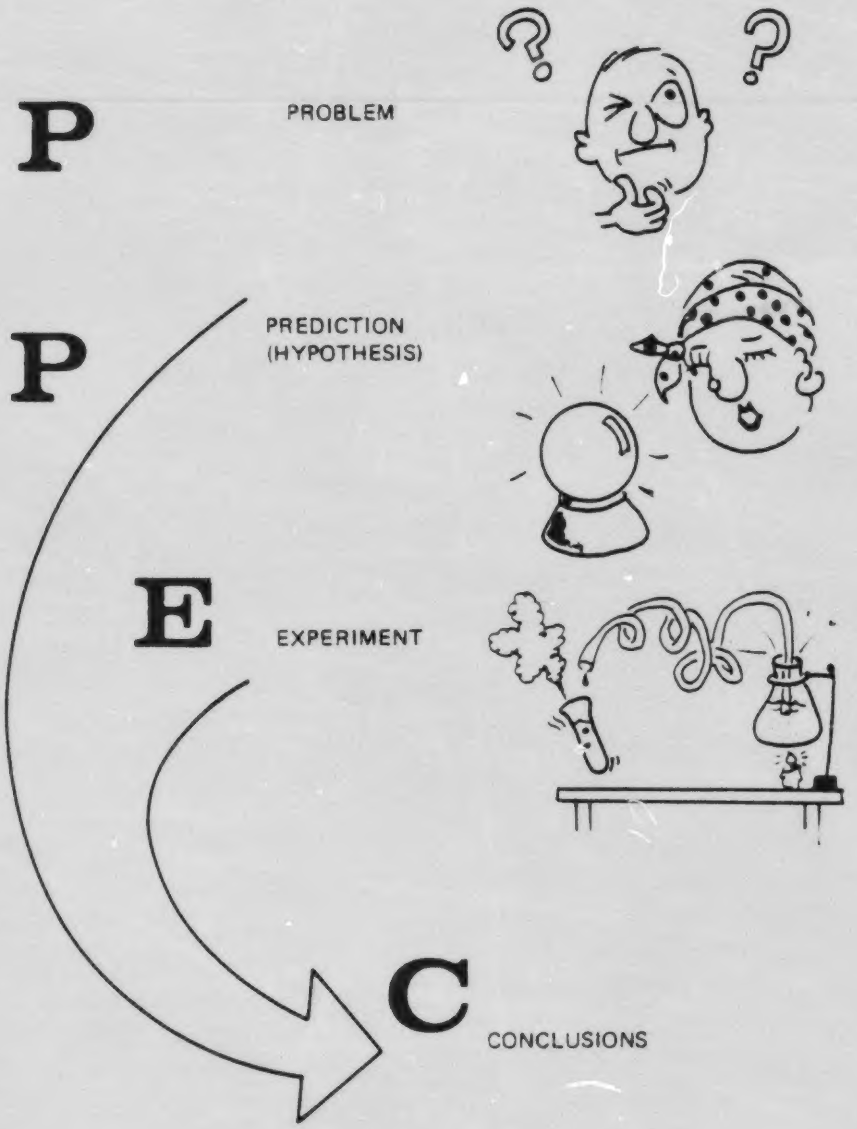
P
PROBLEM
P
PREDICTION (HYPOTHESIS)
E
EXPERIMENT
C
CONCLUSIONS

Figure A-1. The Elements of a Scientific Approach - Problem Prediction Experiment Conclusions or PPEC Method

SCIENTIFIC METHOD

Unit A_K (Approximate Grade Level K)

OVERVIEW

This lesson gives the students exposure to the scientific method, (Predicting, observing and drawing conclusions) by having them participate in a "sink-float" experiment which requires its utilization. Through (1) guessing which objects will float and which will sink, (2) watching which did sink and which did float, and then (3) deciding which kinds of things usually float, and what kinds of things usually sink.

LEARNING OBJECTIVE

Kindergarten students will demonstrate an awareness of the scientific method (guessing, watching and deciding) through participation in a sink-float experiment as measured on a behavioral checklist by the teacher.

EVALUATION

Because this objective is concerned with "awareness" and not with knowledge, evaluation is done by observation of "engaged" behavior. To successfully meet this objective, a student must demonstrate "participation" in this experiment. The enclosed observation sheet Figure 9 gives the teacher a tool for these observations.

SPECIAL MATERIALS

- Clear containers to hold water
- Variety of small objects: some of wood, some of metal (e.g. wood blocks, wooden toys, paper clips, jacks, etc.)

VOCABULARY

Scientist, sink, float, experiment

EXTENSION EXERCISES

- The class can engage in any other kind of experiment which will allow them to utilize the scientific method: (e.g. what kinds of things would fly best? etc.)
- The class could move on to lesson B_K and apply the scientific method to the plant experiment.

LESSON PLAN

1. This lesson will work best if each student is able to directly manipulate the items involved in the experiment rather than merely being an observer. It is best to set up the classroom such that every 2-4 students have a container of water and a set of objects to work with.

2. Introduce the lesson as a problem. "We want to try to figure out the rule for when things will float and when they will sink." (This may need a demonstration of sinking and floating."

3. Have the class suggest some rules for when things will float/sink.

4. Have every group sort their collection of objects into two groups: those that they think will float, and those that they think will sink.

5. Have each group test its objects to see if their guesses were correct. (If you have given every group identical sets of objects,

you can design a worksheet which will allow them to record their results/otherwise have them make a pile of "sinkers" and a pile of "floaters."

6. Talk about what was done: Include the following points:

- We were scientists – we did experiments.
- An experiment is a test where you:

  a. Guess what will happen

  b. Watch what does happen, and

  c. Decide if you were correct in your first guess.

NOTE: It is also possible to have the students perform the experiment comparing metal to wood. In other words: (a) Guess if metal will float. Guess if wood will float. (b) Test metal objects and test wood objects, and (c) decide if you were correct in your first guesses.

RESOURCES

See the Instructional Bulletin of L.A. Unified School District # EC 483-2978, "Floating and Sinking Things" for expansion of this lesson with activity sheets.

See "Clayboats" produced by the Workshop for Learning Things, Watertown, Mass. (C.F. Educational Development Company, Boston, Mass.)

SCIENTIFIC METHOD

Unit A_I (Approximate Grade Level #1)

OVERVIEW

This lesson is designed to allow the students to reinforce their understanding of the scientific method through application of the scientific method to an experiment. Rather than creating an additional lesson, we will utilize the experiment in lesson B_I which demonstrates the importance of sunlight to plant development. As the lesson is presented and the experiment performed, the teacher should emphasize the steps in the scientific method.

LEARNING OBJECTIVE

The learner will apply the scientific method (Guessing, Watching and Drawing Conclusions) through making a pictograph and written-word record of a light and dark plant experiment.

EVALUATION

Enclosed with the materials for lesson B_I is a representative worksheet (Figure A-2) for writing up this experiment. It allows the student to (1) draw a picture and describe in words what they think will happen, (2) to draw a picture and describe in words what they see happening, and (3) state yes or no to whether their prediction was correct. Successful completion of this worksheet (relative to linguistic facility) demonstrates application of the scientific method.

4.

LESSON PLAN

1. The class is asked: "What do you think will happen if a plant doesn't get sunlight?"

2. Review the scientific method. (GUESSING/WATCHING/DECIDING)

3. How would a scientist decide if our guess about the plant needing sunlight is correct? He/she would set up an experiment.

4. Pass out the lab-report worksheets and define the experiment.

   a. We will cover several of the leaves on this plant with tinfoil so that they can get no sunlight.

   b. We will need to watch it every day for awhile. (It may take up to 2 weeks before you have significant results.)

   c. We will need to make records of the results.

5. Record the experiment on the worksheets. (Figure A-1.) Additional copy of figure is contained in the Applications Section.

6. Observe the plant daily.

7. When you think that you have significant results/record the conclusions.

RECORD SHEET

NAME ______________________

1. THE PROBLEM: ______________________

2. YOUR PREDICTION (YOUR GUESS)

3. OBSERVATION –
WHAT HAPPENED

4. ARE SQUARES 2 AND 3 THE SAME ______________________

Figure A-2. Lab Report Worksheet

SCIENTIFIC METHOD

Unit A_{II} (Approximate Grade Level #2)

OVERVIEW

Working with a deck of cards which describe the steps in the scientific method, students will come to understand that there is a basic sequence to the steps involved in performing an experiment. These cards define the process both with words and pictures as: The problem, the prediction, the observation, and the drawing of conclusions.

LEARNING OBJECTIVE

Students will demonstrate comprehension of the scientific method through correct manipulation of a card deck which contains the sequential steps involved in doing an experiment as observed and recorded by the teacher.

EVALUATION

The teacher simply has to observe and record the students who failed to correctly sequence the deck.

SPECIAL MATERIALS

- Special deck of sorting cards (Figure A-3a and A-3b), also in Appendix A.

VOCABULARY

- experiment, problem, prediction, observation, conclusion, (Scientific)

EXTENSION EXERCISES

- Have the students design their own experiments, have them draw a series of pictures (cartoons) of the various steps involved: (The problem, the prediction, the observation and the conclusion). If you want, it could be an experiment on the moon or someplace else exciting.

LESSON PLAN

1. Pass out the sheets containing the card deck (Figure A-3b) and have the students cut out the decks.

2. Ask the students to guess what the deck represents. Establish that these are the steps in doing an experiment. Have them (either individually or in groups of 2-4) put the cards down in what they feel is the "right order of steps" to perform an experiment.

   NOTE: You may need to go through the cards with the class. This going through may include: (1) reading the big words, (2) translating these big words, i.e. predicting = guessing, etc. and (3) explaining just what is involved in each step.

3. Share the answers of the various groups, and then construct the correct order on the board.

4. Take an experiment the class has performed (e.g. the plant experiment B_I or the Sink Float A_K) and have them describe how they did each step of the scientific method as they performed that experiment.

5. Have them play a game of "War" by allowing two (or more) students to merge their decks. The card which represents the earliest step

in the scientific method always wins. (That means that Predicting captures observing, etc. In the Case of a War, (a time when both players put out the same card) have no cards put face down, and let the next set of cards take both sets of cards.

6. Ask students to take back their own cards (or at least one set). Erase the board and have the students once more place the cards in the right order for performing an experiment. Observe and evaluate.

NOTE: The decks may be saved, and brought out again, as an introduction to each experiment the class will perform.

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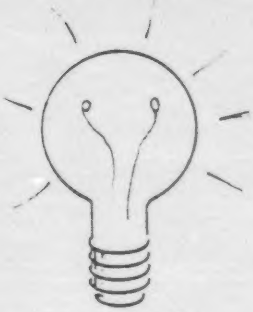
KINDS OF ENERGY – WORKSHEET



MECHANICAL
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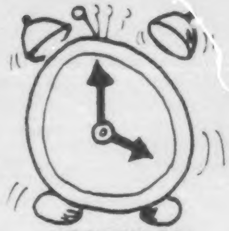
HEAT______



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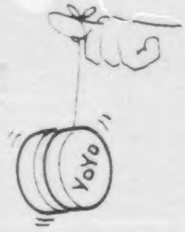

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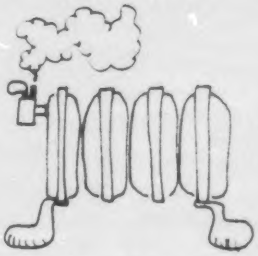

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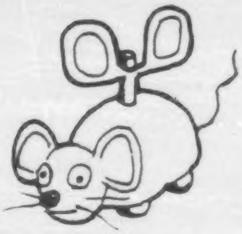

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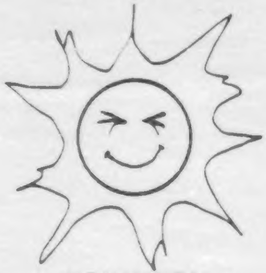

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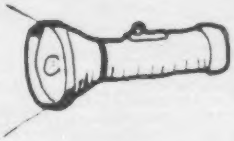

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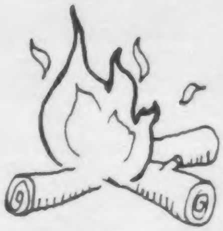

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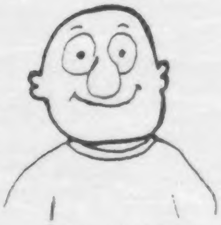

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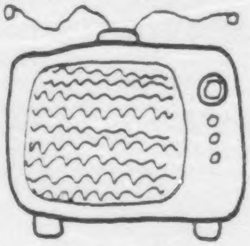

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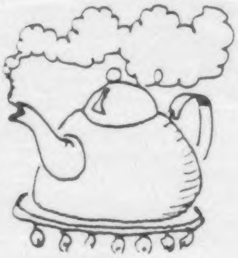

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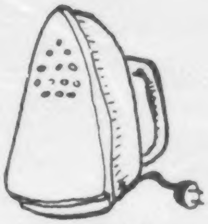

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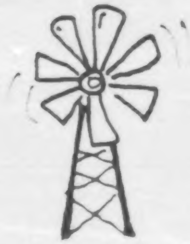

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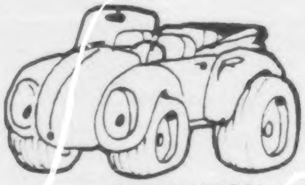

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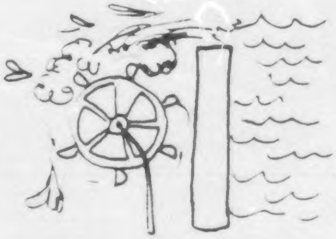

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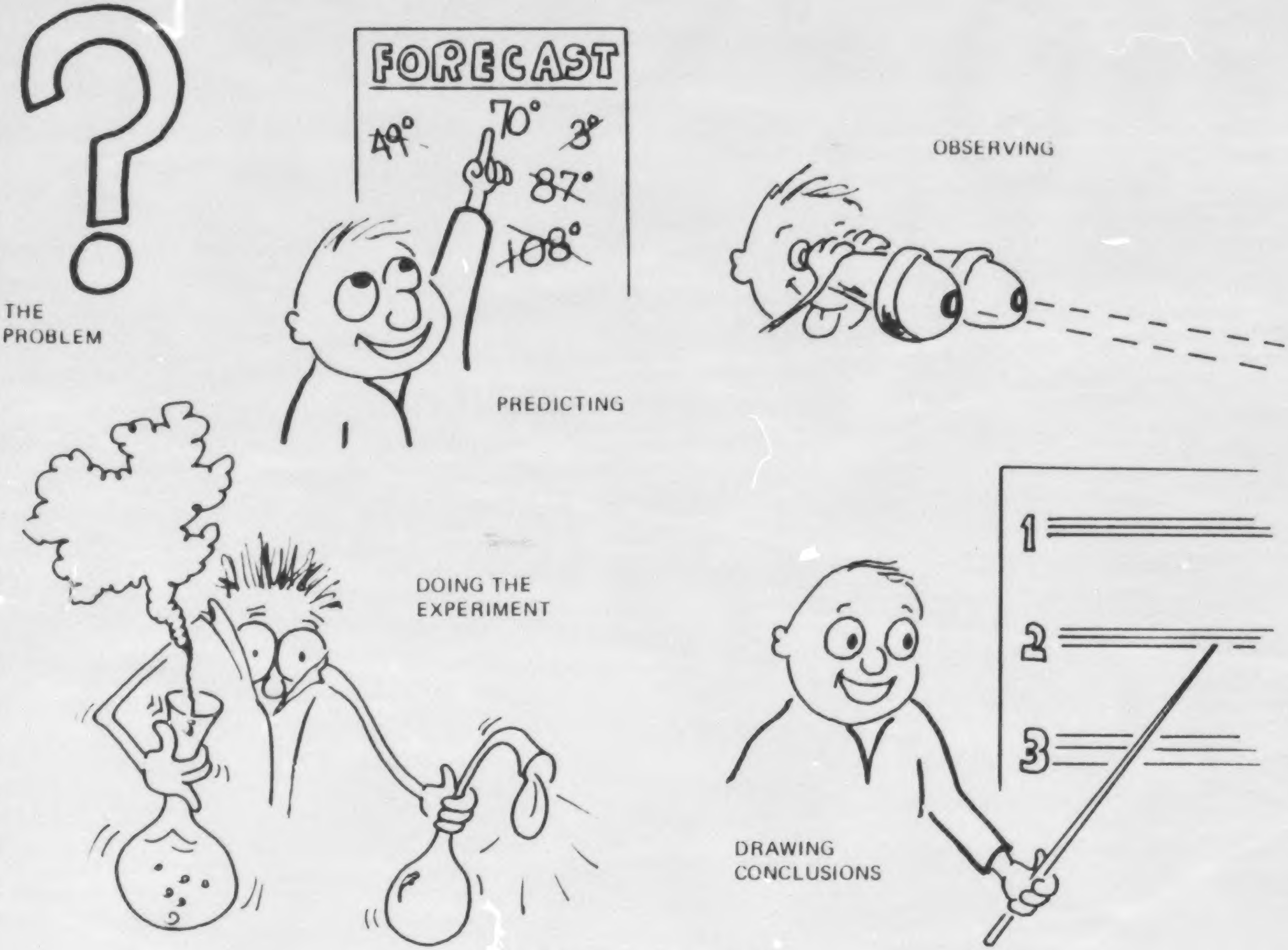

THE PROBLEM
FORECAST
49°
70°
3°
87°
108°
PREDICTING
OBSERVING
DOING THE EXPERIMENT
1
2
3
DRAWING CONCLUSIONS

Figure A-3a. PPEC Method

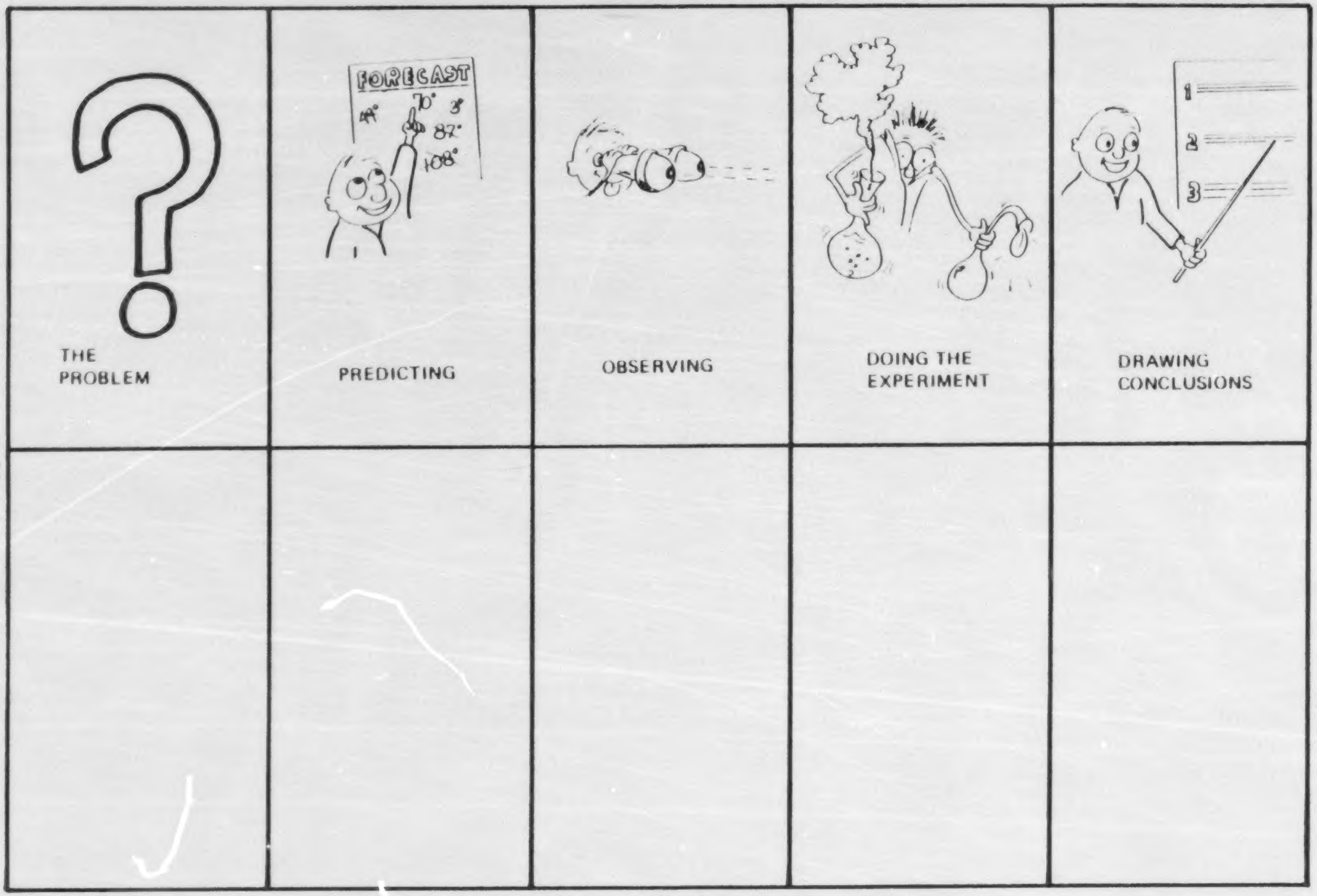

THE PROBLEM
FORECAST
49°
70°
8°
87°
108°
PREDICTING
OBSERVING
DOING THE EXPERIMENT
1
2
3
DRAWING CONCLUSIONS

Figure A-3b. Sample for Card Deck PPEC

SCIENTIFIC METHOD

A_{III} (Approximate Grade Level #3)

It was felt that there is no need for an independent lesson for the scientific method for grade three. The lesson found in A_{II} will do the job nicely.

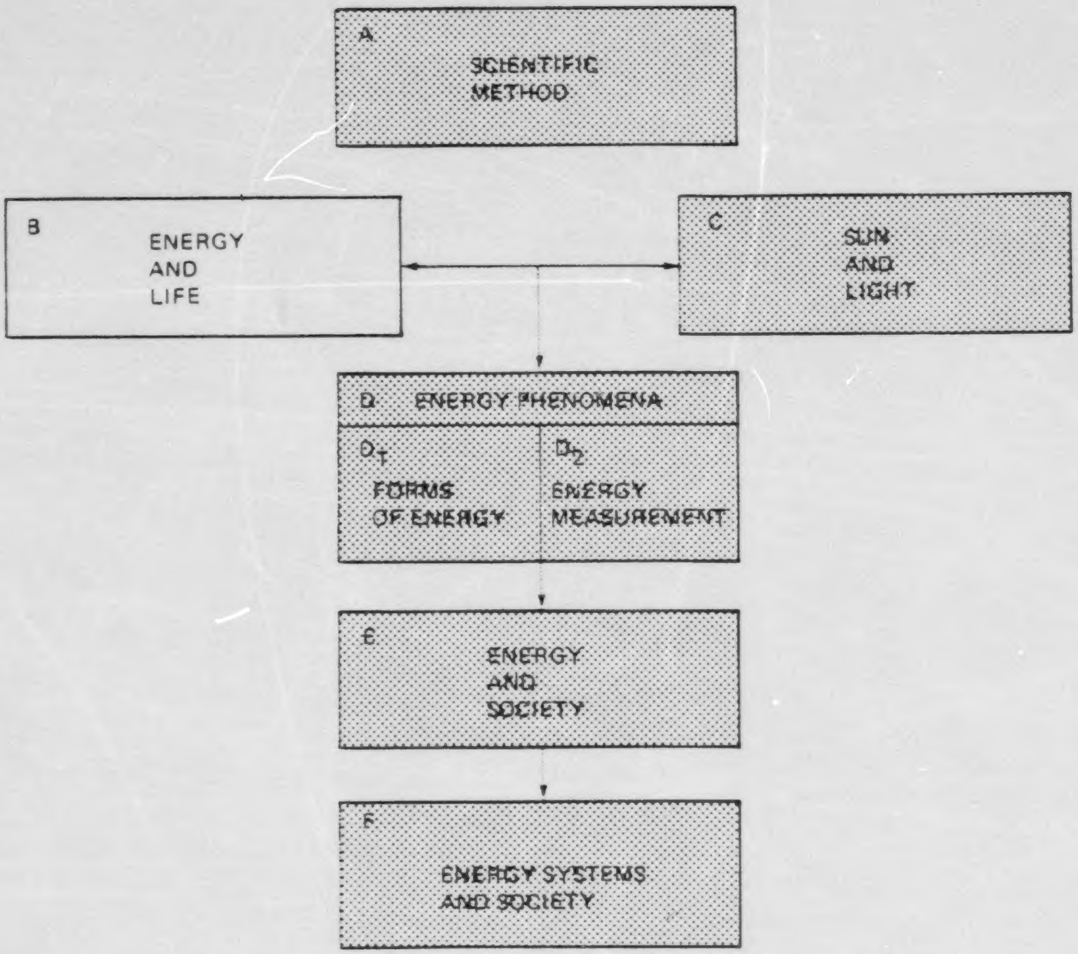
a. If this is the first contact a class will have with a solar-energy or science curriculum, the 2nd grade lesson for this objective will serve as an excellent introduction to the scientific method.

b. If this is part of an on-going use of this curriculum, a few minutes with the Scientific Method Sequencing deck, will serve as an adequate review of concepts.

The Scientific Method: Problem, Prediction, Observation (Experiment) and Conclusion should be utilized in the performance of every class experiment. In addition, the Scientific Method is utilized in Lesson C_{III}.

A_{IV} - A_{VI} USE PPEC APPROACH

As applicable in Sections B thru F.


A
SCIENTIFIC
METHOD
B
ENERGY
AND
LIFE
C
SUN
AND
LIGHT
D ENERGY PHENOMENA
D_1
FORMS
OF ENERGY
D_2
ENERGY
MEASUREMENT
E
ENERGY
AND
SOCIETY
F
ENERGY SYSTEMS
AND SOCIETY

ENERGY AND LIFE

2

THE SUN IS ESSENTIAL TO LIFE

Life, as we know it on earth, could not exist without the sun. The plants take the sunlight and using a process called photosynthesis, are able to take the solar energy and change it into food and allow the plants to grow. The sunlight that strikes the surface of the earth, around the plant, warms the soil and this warmth, in turn, increases the rate of growth of the plant. As the sun's energy falls on the ocean and other bodies of water, the water is warmed and some evaporates or turns into water vapor. This water vapor eventually becomes the clouds we see in the sky. The warmth of the sun also heats our atmosphere differently in different places depending on how well that part of the earth can see the sun at a particular time. The result is that because of this difference in heating, winds blow and the clouds move. When the clouds move over our plants in the warm soil, there may be rain again causing the plants to grow.

Man himself has also been kept alive and warm by the sun. Without the food that is grown on earth, man could not exist. All the energy that we have on earth can be traced back to the sun. The fossil fuels are solar energy that was used thousands of years ago to grow plant life and that plant life, in turn, decayed and eventually became the oil and coal and natural gas we have today. If one accepts the theory that the earth is some of the sun's material that broke away, then even the atomic energy we have on earth can be traced back to the sun.

Students seem to sense this close relationship between life and the sun and therefore, teachers have found that using this general subject matter provides excellent topics for students expressions. Various classrooms have asked the students to draw pictures of life without the sun or looking at it in a more positive nature, life with the sun. Students may be asked to draw plants growing in the sun, people sitting in the sun, people planting fields in the sun, the sun making the winds blow or any other theme they may choose using the sun. The students may be asked to draw pictures of the sun, but care must be taken to always warn the students DO NOT EVER LOOK DIRECTLY AT THE SUN. While the sun is our friend and essential to life, it is a very powerful and strong friend and if they look at it directly, the sun could accidentally harm their eyes.

Another way of showing the inter-relationship of the sun and life, is by having the students grow some plants in class. These may be indoor plants that they care for or seeds put upon wet blotter paper or small dishes of soil.

SOLAR ENERGY CHAIN

Solar Energy is energy that comes from the sun. It is called Solar flux and is energy that is given off (radiated) by the sun as light (solar radiation). We know that the sun has been around for a very long time, billions of years. When life began, a way of storing solar energy also came into being. Plant and animal life that lived long ago died and decayed into what we call fossil fuels. Fossil fuels may be found underground in the form of coal, petroleum and natural gas.

Solar energy is also instrumental in producing other forms of energy that we can use. The sun warms the air masses on earth in such a way as to produce winds. Wind energy can be used to drive windmills which may turn generators to produce, or to operate other mechanisms such as pumps or electricity. Tidal energy is not caused by weather, but by the sun's pull on the earth. High and low tides in the ocean reoccur each day. Dams may be used in such a way to store this energy, but a very high and low tide is needed. The La Rance estuary on France's Northwest coast has such tides, and they make use of their rise and fall to generate electricity.

Another form of energy coming from the ocean is called thermal energy and is caused by the sun's heating of the surface of the ocean. The difference in temperature between the surface and the ocean depth can be utilized to generate electricity.

Biomass means all plants and animals, living or dead, and their waste products such as manure. Biomass conversion involves ways to convert energy stored by biomass into useful forms of energy such as fuels to replace fossil fuels. We humans convert biomass, (i.e. food) into energy that is needed to carry on body functions. An example of a more useful form of biomass conversion replacing fossil fuels is wood burning which may provide heat, or production of gases such as methane from human and animal wastes that be burned for heat. Garbage dumps produce quantities of methane gas.

Solar flux can also be converted directly into electric power by photovoltaic cells. Photovoltaic or solar cells are made of certain elements which produces an electric current when the sun strikes their surfaces.

The energy radiated from the sun is called solar energy and is, as we see, the cause of other forms of energy as well.

The solar flux is a constant source of energy and can be measured as a rate of energy (energy per unit of time) available per unit area. Here it is given as a watts per meters squared. This number is the amount received at the edge of the atmosphere.

$$\frac{\text{Energy}}{\left(\text{Unit Time}\right)} \times \frac{1}{(\text{Unit Area})} = 1353 \ \frac{\text{Watts}}{m^2}$$

$$\frac{\text{Energy}}{\left(\text{Unit Time}\right)} = \text{power (watts)}$$

Since light is reflected or absorbed by the Earth's atmosphere as it approaches the ground, the solar flux will be less than at the edge of the atmosphere.

A chart of solar energy and various energy forms is shown in Figure B-1 as the Solar Energy Chain.

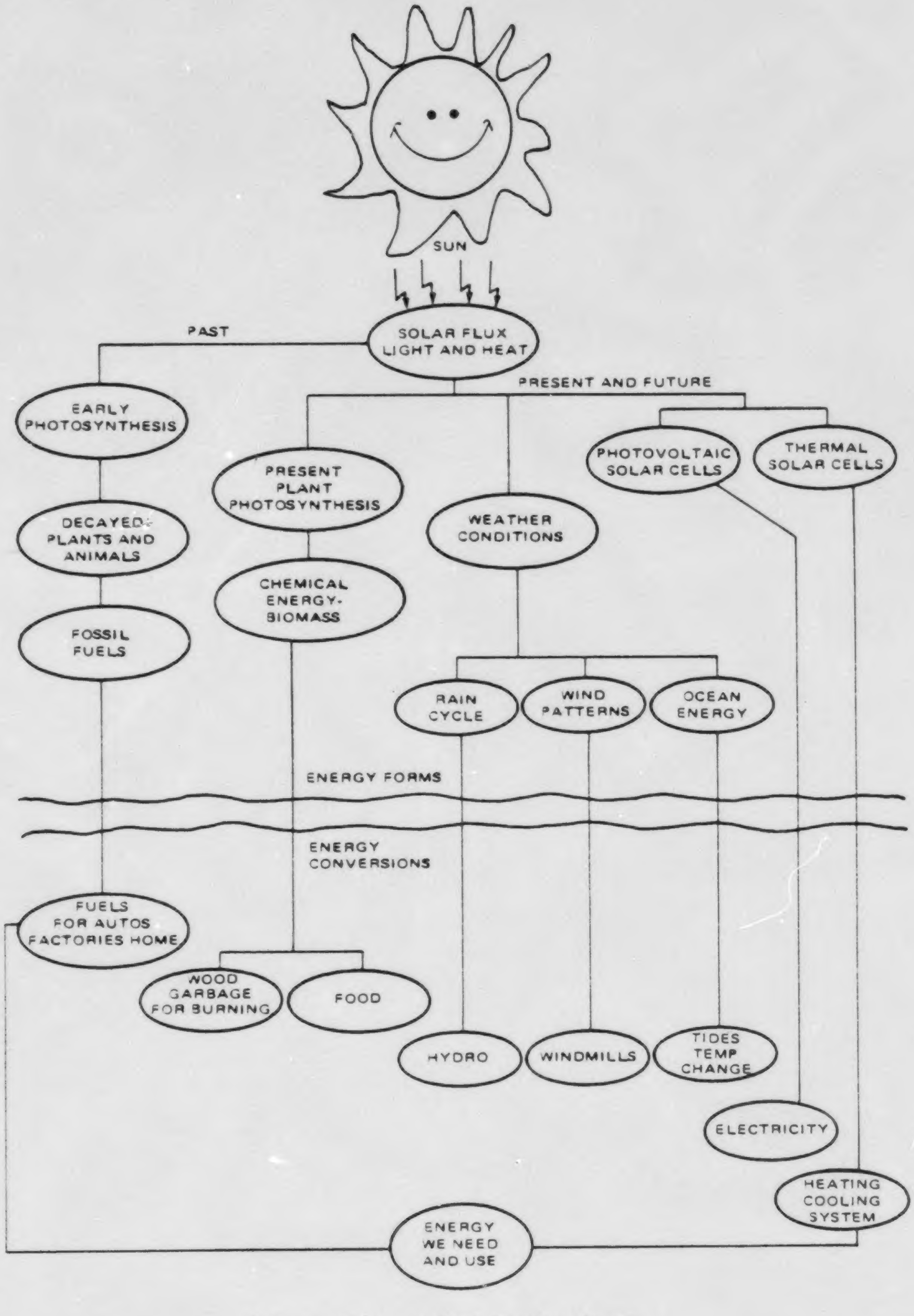

SUN
SOLAR FLUX LIGHT AND HEAT
PAST
PRESENT AND FUTURE
EARLY PHOTOSYNTHESIS
DECAYED PLANTS AND ANIMALS
FOSSIL FUELS
PRESENT PLANT PHOTOSYNTHESIS
CHEMICAL ENERGY-BIOMASS
WEATHER CONDITIONS
PHOTOVOLTAIC SOLAR CELLS
THERMAL SOLAR CELLS
RAIN CYCLE
WIND PATTERNS
OCEAN ENERGY
ENERGY FORMS
ENERGY CONVERSIONS
FUELS FOR AUTOS FACTORIES HOME
WOOD GARBAGE FOR BURNING
FOOD
HYDRO
WINDMILLS
TIDES TEMP CHANGE
ELECTRICITY
HEATING COOLING SYSTEM
ENERGY WE NEED AND USE

Figure B-1. Solar Energy Chain

WHAT MAKES THE WEATHER ON EARTH

Teacher and Student Reader

Although some winters and summers are colder or warmer than others, on the whole the earth's weather conditions over the last many years, have remained roughly constant. This is due to the fact that the motion of the winds on earth and the ocean currents continually are distributing the energy of the earth over this sphere. Winds occur because the warmer air near the equator rises, and its place is taken by cooler air flowing from the North and South Poles. In addition, since warm air can hold more water vapor than cool air, the equatorial air contains more water obtained by the evaporation from the ocean and carries it towards the Poles. As the air cools during its journey towards the colder polar regions, the water vapor condenses and falls as rain. Thus, while the heat and moisture absorbed by the atmosphere near the equator are carried toward the Poles, cooler, drier air flows from the polar regions towards the equator. The cool, dry air is then heated and absorbs moisture. The cycle is completed as this heated air rises and moves again towards the Poles.

The details of this flow are affected by the nature of the surface over which the winds pass (i.e., whether the winds flow over land or water, flat land or mountaineous regions, green moist fields or dry deserts, etc.). The daily weather conditions depend heavily on the local terrain, the nearness to bodies of water, the type of ground cover, and in many cases, the activities of man.

ENERGY AND LIFE

Unit B_K (Approximate for Grade Level #K)

OVERVIEW

Through a combination of (1) acting things out, (2) class discussion, and (3) singing a modified version of "Old MacDonald's Farm", the students will gain an understanding that the Sun is essential for life on earth.

LEARNING OBJECTIVE

Kindergarten students will demonstrate an awareness that the sun is essential to life through participation in a series of class activities as measured by the teacher on a behavioral check list.

EVALUATION

Because this objective is concerned with "awareness" and not with knowledge, evaluation is done by observation of "engaged" behavior. To successfully meet this objective, a student must demonstrate "participation" in this experiment. The enclosed obervation sheet gives the teacher a tool for these observations.

SPECIAL MATERIALS

- lamp or flashlight

VOCABULARY

Sun, Warmth, light, dark, Energy

EXTENSION EXERCISES

None Indicated.

LESSON PLAN

1. One student is asked to play the sun. He/she stands on a chair or table with a light. Everyone else is asked to play people who are asleep. Turn out the lights in the classroom. Have the student who is the sun point his/her light on the other students who "wake-up" and begin their day when the light is shining on them, and who go back to sleep when the light leaves them.

2. Have other kids play the sun.

3. Switch the class to playing stocks of corn or wheat, etc. Let them grow a little every time there is sunlight, but have them stop growing when there is no sunlight.

4. Play a "corn is growing" game like red-rover. See who can be the first corn-stock to "grow-up" when the light is shining. A child can grow only when the light is shining on him/her. If he/she is caught moving without sunlight, he/she has to go back to being a seed.

5. Discuss how sunlight effects us:

   a. We feel warm
   b. We can see
   c. It lets plants grow

6. Teach the new "Old MacDonald" and have the class act it out.

7. Here is the text:

(Chorus)

Old MacDonald had a farm,

eee iii eee iii oooo,

And on his farm there was sunshine everyday,

eee iii eee iii oooo,

(Verse)

The sun shone on some happy pigs,

eee iii eee iii oooo,

With an oink, oink here and an oink, oink there,

eee iii eee iii oooo,

(Chorus)

The sun shone on some growing wheat

eee iii eee iii oooo,

With a (wind noise) here and a (wind noise) there,

eee iii eee iii oooo,

(Chorus)

The sun shone on some smiling cows,

eee iii eee iii oooo,

With a ha ha moo here and a ha ha moo there,

eee iii eee iii oooo,

(Chorus)

The sun shone on some flowing creeks,
eee iii eee iii oooo,
With a gurgle, gurgle here and a gurgle, gurgle there,
eee iii eee iii oooo,
The sun shonw on some squeeky squirrels,
eee iii eee iii oooo,
With a squeek, squeek here and a squeek, squeek there,
eee iii eee iii oooo,

(Chorus)

The song can go on using additional clucking chickens, quacking ducks, and any number of other barnyard animals and sounds you may think of.

- After the song, discuss with the students how the sun makes things grow, both things that grow in the ground and animals; and how we could not live without it.

SPECIAL NOTES:

In addition to the song, the teacher can call the students' attention to things in the class that need the sun such as any plants, animal, or students that may be in the class. The students could be taken on a short walk outside to further look for things that need the sun to live and grow.

B_I

ENERGY AND LIFE

Unit B_I (Approximate Grade Level #1)

OVERVIEW

This lesson allows the students to apply the scientific method to an experiment which demonstrates how the sun is essential to green plant growth. The class will fill out "lab-reports" on an experiment in which one leaf of a green plant is covered with tin-foil to prevent its receiving sunlight. Through a combination of words and pictures, each student will record his/her predictions, observations and conclusions (Figure A-2).

LEARNING OBJECTIVE

First grade students will demonstrate a knowledge that the sun is essential to plant life through participation in a plant-leaf experiment which will be observed through their completion of a "lab-report."

EVALUATION

As we have noted in lesson A_I, this lesson serves as the completion of two objectives: (1) in mastery of the scientific method, and (2) a knowledge that the sun is essential for green-plant growth. Both of these objectives will be evaluated through the lab-report work sheet. To meet objective A_I, the conclusion statement must be that "Plants need sunlight."

SPECIAL MATERIALS

- 1 green plant
- Aluminum foil
- Lab-report Worksheets

VOCABULARY

- Scientist, predict, observe, experiment, conclude

EXTENSION EXERCISES

- The class could see how plants grow under colored light by putting colored cellophane over the end of a cardboard box, and growing the plant in the box.

LESSON PLAN

1. The class is asked: "What do you think will happen if a plant doesn't get sunlight?"
2. Review the scientific method. (GUESSING/WATCHING/DECIDING)
3. How would a scientist decide if our guess about the plant needing sunlight is correct? He/she would set up an experiment.
4. Pass out the lab-report worksheets and define the experiment (Figure A-2).
    a. We will cover several of the leaves on this plant with tinfoil so that they can get no sunlight.
    b. We will need to watch it every day for awhile. (It may take up to 2 weeks before you have significant results.)
    c. We will need to make records of the results.
5. Record the experiment on the worksheets.
6. Observe the plant daily.
7. When you think that you have significant results/record the conclusions.

ENERGY AND LIFE

Unit B_{II} (Approximate Grade Level #2)

OVERVIEW

In lesson B_I the students observed a plant-leaf experiment and recorded the data on a simple worksheet. In this lesson, the students will repeat that lesson with two changes: (1) They will perform the experiment for themselves, and (2) they will cover the whole plant and not just one leaf.

LEARNING OBJECTIVE

Second-grade students will demonstrate knowledge of the sun's essential relationship to all green plant life, through participation in a plant-light experiment which will be measured by their completion of a work-sheet lab-report.

EVALUATION

As we have noted in lesson A_{II}, this lesson serves as the completion of two objectives: (1) in mastery of the scientific method, and (2) a knowledge that the sun is essential for green-plant growth. Both of these objectives will be evaluated through the lab-report work sheet. To meet objective A_{II}, the conclusion statement must be that "Plants need sunlight."

MATERIALS

- 5 or 6 small houseplants
- a dark room or cardboard boxes
- worksheets

VOCABULARY

Scientific, prediction, experiment, observation, conclusion, sun, solar, photosynthesis, research

EXTENSION EXERCISE

- Students can see if plants need all colors of light, by giving the plants a single colored light source either by putting them in a closet with a colored bulb, or by growing them in a box with colored cellophane.

LESSON PLAN

1. If possible, review the class' experience with lesson A_I (last year's plant-leaf experiment).

2. Review the scientific method (see A_{II}).

3. Introduce the following problem: We are going to design an experiment which will let us see if all plants need sunlight in the same way. Let the class help design the experiment.

4. The basic design should be as follows:

   a. A team of students will be responsible for each plant.

   b. The plant will be placed in the dark (either in a closet, cabinet or under a cardboard box) and will be watered regularly.

   c. Every day, the team will check the progress of the plant.

5. The class should use the lab-forms and fill out their predictions for this experiment. (Most people will predict that the plant will die and wither; actually it will probably get taller and grow very white.)

6. When you have monitored the experiment, compare the results. Do different kinds of plants and how they react differently.

7. Discuss photosynthesis; how plants turn sunlight and CO_2 plus H_2O into food.

SPECIAL NOTES

The research teams should daily observe their plant to see how it is doing. There is the possible danger of eventually killing the entire plant if the experiment goes on for too long a period unobserved. It should be be noted that some plants have a much better ability to survive in darkness than others, i.e. the difference between outdoor and indoor plants. Leave room to add plants later.

ENERGY AND LIFE

Unit B_{III} (Approximate Grade Level #3)

OVERVIEW

The students are shown how the sun's energy may be used directly or indirectly in relation to maintaining life on earth. A special set of cards are utilized that will allow the students to determine either that the card illustrates a direct use of sunlight or an indirect use.

LEARNING OBJECTIVES

Third grade students will demonstrate knowledge of the essential relationship of the sun to all life forms on earth and demonstrate knowledge of the difference between direct use of the sun and indirect use of the solar energy thru accurate card sort between direct and indirect dependence as recorded on a teacher's checklist.

EVALUATION

The teacher simply must observe and record the number of students who fail to sort cards correctly.

MATERIALS

- Film strip "Life Depends on Sunshine"
- 3 x 5 cards

VOCABULARY

Solar, direct, indirect, energy, work, fossil, fuel, photosynthesis

EXTENSION

Invent other card games.

LESSON PLAN

1. Start with the question: "Who had any sun for breakfast this morning?" When someone answers I did — establish what they ate their sun in. (In which kinds of foods)

2. Show the filmstrip "LIFE DEPENDS ON SUNSHINE".

3. Give every student six 3 x 5 cards (blank).

4. Draw big 3 X 5 cards on the board, and trace an energy chain. The sun, to a plant, to an insect, to a bird, to an animal, etc.

5. Have every student create their energy chain and draw it on the six cards.

6. Have the students trade cards with someone else and try to put their chain in order.

7. Have the students play a game of war, where whoever is closer to the sun's original energy wins.

8. Reverse the rules so that whoever takes energy from the previous source wins.

9. Have the students sort the cards into 2 piles/those which get their energy directly from the sun, and those which get it indirectly.

10. Ask the original question - "Who ate the sun for breakfast this morning?"

THE SUN, EARTH AND WEATHER

Unit B_{IV} (Approximate Grade Level #4)

OVERVIEW

As a classroom demonstration or a group experiment, the students make a small hot air balloon to study how warm air will rise. Then in other group experiments or demonstrations, the students will see how water can take 3 forms; gaseous, liquid, and solid. They will also see how water evaporates and can be made to condense, illustrating that warm air can contain more moisture in vapor form than can cool air.

LEARNING OBJECTIVES

Students will be introduced to basic concepts that determine the weather on earth. Students will have re-emphasized the concepts of light coming at direct or oblique angle to change the energy per unit area; students will be shown the concept of how warm air rises (the driving force behind the wind patterns on the earth) and students will be introduced to the concept that the air can contain moisture.

EVALUATION

The students will demonstrate a knowledge of the fact that warm air will rise and that warm air can contain more moisture in a vapor form than can cool air. The students will demonstrate an understanding of how light energy that shines more directly on a surface is more intense than light energy coming in from an angle.

SPECIAL MATERIALS

- A two pound coffee can
- Some paper clips
- Some ice cubes
- A can of sterno fuel
- A large glass
- A small sauce pan
- (Optional) A large light bulb or a heat lamp in a socket attached to a clamp (so that the light bulb may be clipped to the back of a chair.)
- A light weight large plastic bag (such as a dry cleaning bag with NO HOLES IN IT).

VOCABULARY

Solid, Liquid, Vapor, Evaporate, Condense

LESSON PLAN

The teacher should review and use information contained in C_{IV}, the effect of the earth's tilt on the amount of energy flux (that is energy per unit area) that is received on earth. The teacher will pose the question to the students, "Why is it that the regions around the equator continually get hotter and hotter and those at the poles get colder and colder?" (Heat energy is transferred between the poles and the equatorial regions through wind motions and ocean currents. The wind circulations pattern from the equatorial region to the poles is driven by the warmer moisture laden air in the equatorial region rising, while the dryer cold air from the pole regions flows in. This circulation pattern also moves water vapor from the equatorial regions out towards the polar regions). The teacher will emphasize that winds can affect the movement or transfer of energy and that these winds occur because warm air rises. The teacher may suggest that the class conduct an experiment with a small hot air balloon to prove this to themselves. (In the classroom the air at the ceiling is warmer that that at the floor.)

ACTIVITIES

(Optional) — To further enhance the concept of energy being spread over areas when it does not come directly normal to the surface, the following optional demonstrations can be carried out.

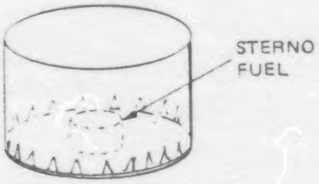
- Attach the lamp holder to the back of a chair with a heat lamp screwed in.
- Aim the lamp directly outward in horizontal line.
- Turn on the lamp.
- Have students put their hand approximately 3 to 4 ft from the lamp, first with their hands at right angles to the flow of the lamp and then tilting their hands away.
- Have the students observe when their hand is the warmer, i.e., receiving the most heat energy. This should occur when their hand is perpendicular to the lines of rays coming from the lamp.

Warm Air is Less Dense Than Cool Air and Therefore Rises

- Take a beverage can opener, "church key", and on the end of the can that has not been opened, punch a series of holes along the side walls of the container (See Figure).

- Attach several paper clips around the open end of the plastic bag (preferably a dry cleaning bag with no holes).

- Open the can of sterno fuel and place it in the bottom of the coffee can (the end that you have punched all the holes in).



- Light the sterno fuel.
- Taking care not to bring the bag in contact with the flame (and set it afire), place the bag over the can.

NOTE: The flame from the sterno fuel will draw in air through holes that have been punched into the can. This air will be heated and rise to fill the plastic bag.

- When the plastic bag has been well filled with the warm air, release it.
- Have the students observe what happens to the bag. Does it rise or fall?
- The experiment can be repeated if desired; if not, replace the top of the sterno to extinguish the flame.

NOTE: After a short period of time, the air in the bag will cool and condense. When this happens, the bag will fall to the floor.

- Have the students discuss the experiment. If they were hot air balloonists, would they want to fly in winter when the air is cool or in summer when the air is warm? (In winter, the air being cooler, will allow the balloon to fly more easily).

THE DIFFERENT PHASES OF WATER

- Take the glass and put ice cubes and water in it.
- Observe what happens to the outside of the glass. The cool glass condenses the water vapor that is present in the air. These droplets of water then collect on the outside of the glass. This shows that the warmer room air does contain moisture or water in vapor form. When the air is dramatically cooled by the cold glass wall by the chilled water, the moisture is forced out of the air and condenses on the outer wall.
- Take a small sauce pan and fill it with ice cubes.
- Take the can of sterno fuel and light it.
- Place the sauce pan with the ice cubes over the flame.
- Observe how the water in a solid state (ice) melts to a liquid state (liquid water). Then the heat of the flame continues to act on the water liquid causing it to boil and vaporize.
- Take a piece of glass or other cool surface (i.e., piece of metal or any other cool material); place this material about one foot above the sauce pan.
- Observe how water condenses on the surface of the cool material. The water vapor forced into the air by the boiling action in the sauce pan comes in contact with the cool surface of the glass or metal. The hot air over the top of the frying sauce pan can contain much moisture. However, when it is cooled by the material held over the sauce pan, the air cannot hold this moisture and the liquid is forced to condense it.

- You may discuss with the students the concept of dew forming in the morning. During the day, air heats up and through evaporation, obtains moisture. During the night, the air cools and since cool air cannot contain as much moisture as hot air, the water is forced to condense out upon the leaves and other cooler objects.

SPECIAL NOTES

The students can do some experimentation at home. On a warm and humid day, they may open the freezer door of the refrigerator. (Have them do this experiment fairly quickly to conserve energy.) They should be able to see a "cloud" of cool air falling out of the freezer toward the floor. This cooling of the room air causes the moisture that was in the room air to condense out and form water vapor, i.e., analogous to a cloud.

They should be made aware that winds are not caused by the earth spinning beneath the atmosphere. The earth makes one complete rotation per day. Since the circumference of the earth at the equator is about 24,000 miles, this means that the surface of the earth is moving at about 1,000 miles per hour. The greatest storms do not produce winds anywhere near 1,000 miles per hour.

WEATHER FORECASTING

Unit B_V (Approximate Grade Level #5)

OVERVIEW

Students are introduced and taught the basic symbols used for weather map presentations. Then using this knowledge students (or small teams) share with the class an explanation of weather maps obtained from local newspapers. The class should keep track of both local and national weather conditions.

LEARNING OBJECTIVES

Students are introduced to the methods of recording the weather patterns on earth. Students then use this knowledge in class presentations to help explain the current weather conditions locally and perhaps throughout the nation.

EVALUATION

The students will learn the basic methods of information presentation in weather reporting, i.e., isobars, weather fronts, presentation of temperatures and two other symbols (rain, fog, snow, etc.).

MATERIALS

- Students will cut out and bring into class weather maps obtained from local newspapers.

VOCABULARY

Isobar, Weather Front, Precipitation, Millibar, Visibility, and Isotherm

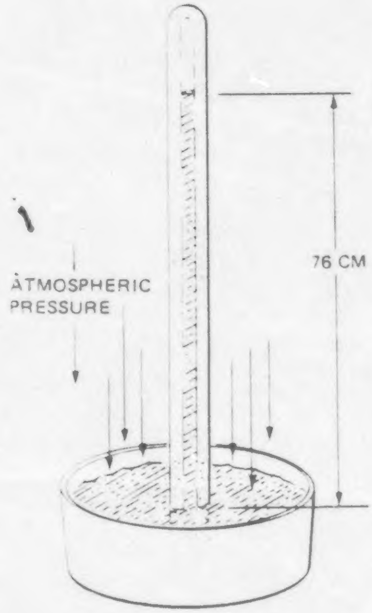
LESSON PLAN

The teacher can ask the questions of the class, what kind of weather can we expect today? This question can then be followed up by what kind of weather can we expect tomorrow? After some class discussion, the teacher can present the concept of weather maps that helps to understand what the weather is and what it might be in the next few hours or days.

ACTIVITIES

- The teacher can first explain the basic features of a weather map.

Atmospheric Pressure: The weight of the earth's atmosphere upon the ground causes an atmospheric pressure. If we were to take a pressure measuring instrument called a barometer, we would find that under normal or standard conditions, the atmospheric weight would force the mercury up the glass tube to a height of 76 centimeters or approximately 29.9". Weathermen draw a line through regions that have the same atmospheric pressure. These lines are called isobars (see the weather map below). This information is important



because normally during rainy or cloudy weather the atmospheric pressure is lower than during sunny, fair weather (see Figure B-2). Notice that in the rainy Portland area, the atmospheric pressure is about 29.3" whereas in the sunnier Southern California area, the atmospheric pressure is 30.0").

Weather Fronts: Where different weather conditions meet is called a weather front. Weather fronts move because of the prevailing wind pattern blowing them along. In the weather map below the small solid line drawn through Portland, Seattle, Great Falls, Jasper, etc., indicates the pattern that the winds are blowing. At the bottom of the map are shown the symbols used for the oncoming cold front, a warm front, or a front that is standing stationary.

Temperature: The temperature of an area is usually given in degrees Fahrenheit or degrees Celsius (the temperatures on the map below are given in Fahrenheit). The insert shows the high temperature and low temperature over a 24-hour period for a particular area. The national map indicates only the high temperature of the day.

Sky Cover: If a circle is drawn at an area with the entire inner part of the circle clear, this indicates that the area has had clear skies. If the circle is completely blackened in, this symbol indicates the percentage of overcast with clouds of the area. Notice in the map that San Diego has had completely clear skies, Los Angeles has about 50% cloud cover, and Boise, Idaho is completely overcast.

Pressure Centers: Poor weather is usually the fault of a low pressure area, whereas good fair weather usually results in high pressure areas. By pressure areas, we mean a region where the atmospheric pressure is either higher or lower than the surrounding areas. For example, on the map below, there is a low pressure area of 29.9 in Mexico surrounded by higher pressure areas. A similar situation exists out in the Atlantic Ocean off the coast of North Carolina. There is a higher pressure area centered over the southern United States in the map below.

Other Weather Symbols: Weather people use other symbols to indicate various local conditions. Examples of these are shown below.

	RAIN	≡	FOG	∞	HAZE
✶	SNOW	△	SHOWER	R	THUNDER STORM
,	DRIZZLE	▽	HALE	S	DUST

Notice on the weather map Figure B-2, the symbol for snow over the northeastern part of the United States and the symbol of rain over the northwestern part.

- The lesson may be carried out in a variety of manners, at the discretion of the teacher. Some suggestions are the following:

Individual Reporting: Each student as an assignment will bring in a weather map from the newspaper. Then during a specific class time, the student will explain the weather conditions that have existed over the last 24 hours nationally and locally to the rest of the class. Each day, a new student will have the task. The lesson can be continued a few minutes each day for many days in a row.

Weather Teams: A specific group of students who have indicated a desire, may be classified as the "weather team". This smaller group of students then will on a round robin basis, present to the class each morning the weather report.

Weather Monitor: A student may become the weather monitor for a week or other specific length of time. During this period, the students' task will be to report on the weather each morning to the class utilizing the local weather and national weather maps. The task can be assigned to a different student each week.

- The weather forecast each morning should be as on a continuing basis as possible. That is, specific weather fronts, storms, etc., should be followed day by day. During particularly intense or interesting weather, the weather report can stop and review conditions over the last several days.
- Based on what has been occurring, students can make predictions on what they think the weather will be over the next few days.

- It might be an interesting exercise to correlate the student predictions with the weatherman's predictions with what weather actually occurs.

SPECIAL NOTES

As an adjunct to the weather report, it might be interesting for students to also comment at what weather conditions their solar systems might be most effective, at what times they might not expect their solar systems to work well, and other weather conditions such as high wind that might be useful for producing other forms of energy. The weather reports could also emphasize such things as "be sure to bring a raincoat tomorrow", "make sure you have warm clothing", etc.

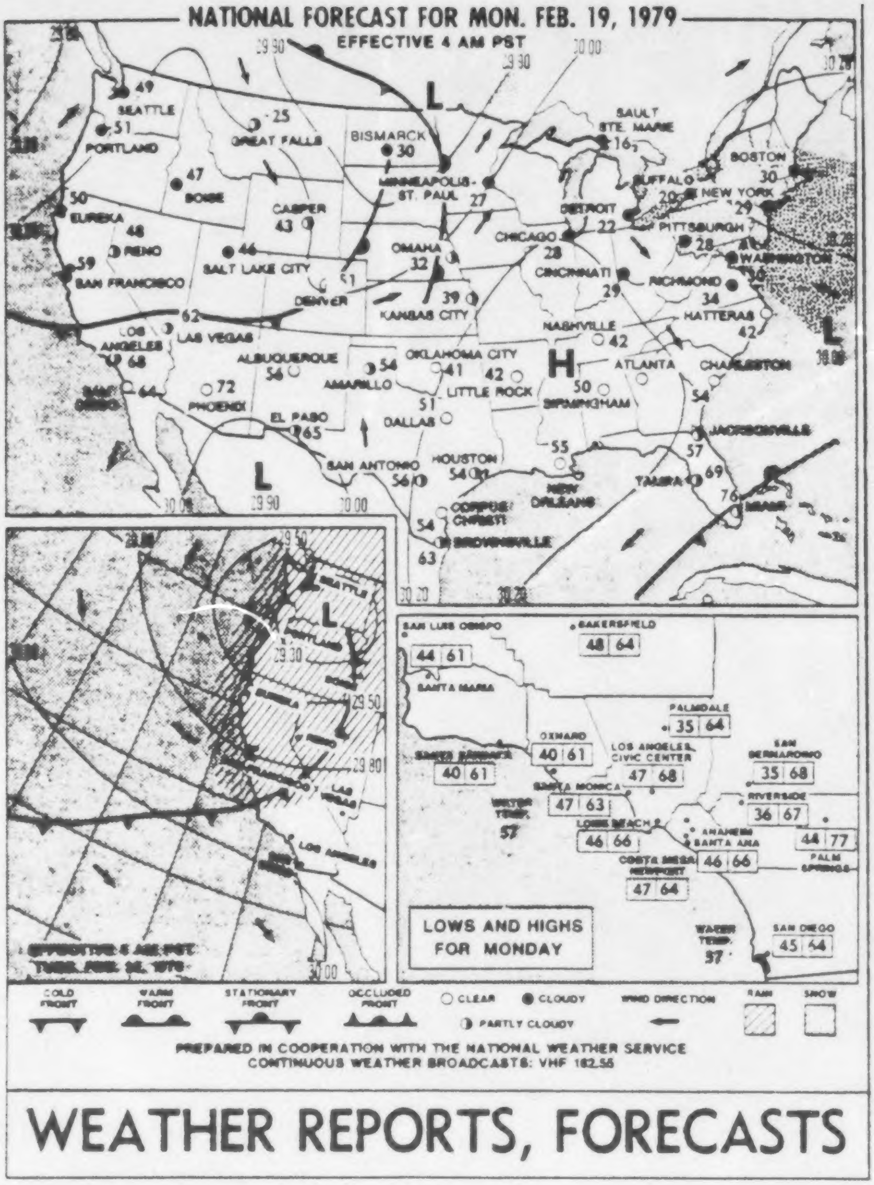

NATIONAL FORECAST FOR MON. FEB. 19, 1979
EFFECTIVE 4 AM PST
SEATTLE 49
PORTLAND 51
GREAT FALLS 25
BISMARCK 30
BOISE 47
EUREKA 50
RENO 48
CASPER 43
SALT LAKE CITY 46
SAN FRANCISCO 59
DENVER 51
MINNEAPOLIS-ST. PAUL 27
OMAHA 32
KANSAS CITY 39
SAULT STE. MARIE 16
CHICAGO 28
DETROIT 22
BUFFALO 20
NEW YORK 29
BOSTON 30
PITTSBURGH 28
WASHINGTON
CINCINNATI 29
RICHMOND 34
HATTERAS 42
NASHVILLE 42
LOS ANGELES 68
LAS VEGAS 62
SAN DIEGO 64
PHOENIX 72
ALBUQUERQUE 56
AMARILLO 54
OKLAHOMA CITY 41
LITTLE ROCK 42
DALLAS 51
EL PASO 65
SAN ANTONIO 56
HOUSTON 54
CORPUS CHRISTI 54
BROWNSVILLE 63
NEW ORLEANS 55
BIRMINGHAM 50
ATLANTA
CHARLESTON 54
JACKSONVILLE 57
TAMPA 69
MIAMI 76
H
L
EFFECTIVE 4 AM PST TUES. FEB. 20, 1979
SEATTLE
PORTLAND
EUREKA
LAS VEGAS
LOS ANGELES
SAN LUIS OBISPO 44 61
BAKERSFIELD 48 64
SANTA MARIA
PALMDALE 35 64
SANTA BARBARA 40 61
OXNARD 40 61
LOS ANGELES CIVIC CENTER 47 68
SAN BERNARDINO 35 68
SANTA MONICA 47 63
RIVERSIDE 36 67
WATER TEMP. 57
LONG BEACH 46 66
ANAHEIM SANTA ANA 46 66
PALM SPRINGS 44 77
COSTA MESA NEWPORT 47 64
SAN DIEGO 45 64
WATER TEMP. 57
LOWS AND HIGHS FOR MONDAY
COLD FRONT
WARM FRONT
STATIONARY FRONT
OCCLUDED FRONT
○ CLEAR
● CLOUDY
◑ PARTLY CLOUDY
WIND DIRECTION
RAIN
SNOW
PREPARED IN COOPERATION WITH THE NATIONAL WEATHER SERVICE
CONTINUOUS WEATHER BROADCASTS: VHF 162.55
WEATHER REPORTS, FORECASTS

Figure B-1. Weather Map

PASSIVE USE OF SOLAR ENERGY

Unit B_{VI} (Approximate Grade Level #6)

OVERVIEW

This lesson brings together many of the principles developed in other portions of the curriculum that dealt with the interaction of the Sunlight and man to present the concept of the passive use of Solar Energy in our homes and buildings. The term passive is used to indicate that the solar energy is utilized solely by proper design and location of the structure, and not by using any outside force such as pumps or fans.

LEARNING OBJECTIVE

Students are introduced to and will explore the passive use of solar energy. Many previous lessons have also carried out this objective, but in this exercise the concept is explicitly stated and developed.

EVALUATION

SPECIAL MATERIALS

- Some small boxes (up to 12" x 12" x 12")
- Some flat pieces of heavy cardboard
- A breadbox type solar oven
- A flashlight
- Some small glass jars with covers
- Some pieces of aluminum foil

VOCABULARY

Passive, thermal storage, reflect, heat transfer

EXTENSION ACTIVITIES

The heat storage experiment can be carried out with coolness. Take the food keeper and place in it a bottle of chilled water, cover it with food wrap and then measure the time it takes the box to warm to room temperature. Perform the same experiment with two or three bottles of chilled water. The extra storage of coolness should take a longer period of time to warm to room temperature.

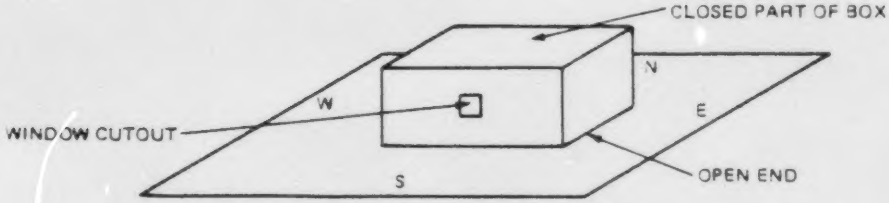
Students can be given an assignment to look at their homes or any particular building and evalute them from the standpoints of how they are situated in relation to the Sun; the location of the windows and whether they are shadowed by foliage - with the objective of determining how the structure will heat or keep itself cool as it relates to solar energy.

LESSON PLAN

As a review, re-examine the subject areas which relate to the angle of the Sun during the day and how its position varies during the year as a function of the local latitude (see lessons in the "B" group). Remind the students that in the northern hemisphere the Sun is generally to the south.

In the following activities, the students will investigate the use of overhangs, proper location of the structure on the lot, and the use of other natural items such as deciduous plants and trees for shading the sun's rays.

1. Have the students obtain small boxes, and use them as a model of a house, cut an opening to scale to approximate a window (see figure).



2. Take a large piece of cardboard and lay it out on a low table or as convenient on the floor. Note: the cardboard should be at least six inches larger than the dimensions of the base of the "house-box".

3. On one edge of the cardboard put a large "S" to stand for the direction of south. In a similar manner, identify "N", "E", and "W" as the directions of the compass on the three other edges.

4. Place the house-box in the center of the larger piece of cardboard, with the window of the box aligned with the "north" edge of the cardboard.

5. Have another student take the flashlight and shine the light from the south edge down onto the side of the house-box at an angle approximating the sun's direction during the winter months (i.e., at a low angle).

6. Have the students observe how much light is shining into the window of the house-box that is on the north side of the box. Obviously, no light gets in! Although this exercise appears simplistic, it serves to emphasize the point, that if you want to warm your home by using the sun, the north facing windows are ineffective in this regard. (In fact, they provide a means for heat to escape through them. Glass, even double pane glass, can lose heat energy to the outside at a greater rate than the solid walls of a building.)

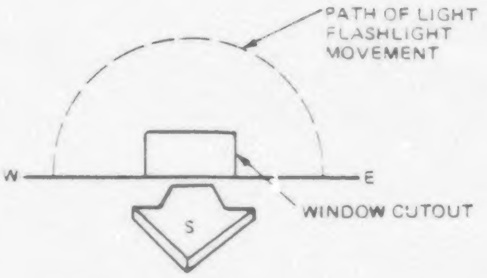
7. Rotate the house-box around so that the window side now faces south.

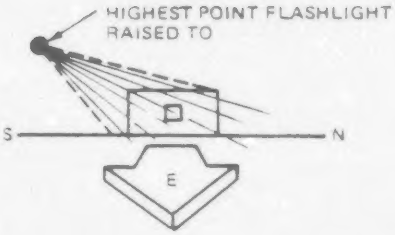
8. Repeat the experiment to confirm the results that heat gain windows should not face north, but can face south.

9. Pose the question now, "Can windows that gain energy for the house also face west or east?"

10. Rotate the house-box again so that now the window side faces east.

11. Have the "sun person" with the flashlight move the light around simulating the sun's position from sunrise to sunset. That is, start off with the flashlight on the floor or table level on the east side of the south edge. Then bring up the light just as the sun rises. Move the light in an arc, so the light is at the highest point above the house box at "noon time" (remember it is winter so do not have the light at noon directly overhead, but still at some angle). Continue with the flashlight until the sun sets in the west. Make a mental note of the position of noon time.





12. Have the students observe that light will shine in through the window during the morning hours before noon time to heat the home, but do not after lunch! (The window facing east will not see the sun in the afternoon.)

13. Rotate the house-box so the window side is on the west. Again have the sun person rise and set the sun. Note now that the house can be heated in the hours after noon. (Because the water vapor content of the atmosphere is greater in the morning hours, the afternoon sunlight is usually more intense than the morning light. Therefore, for heating purposes, the west windows will be somewhat more effective than the east ones.)

14. So far, we have discussed the problem of heating. How may we use passive methods to keep our homes and buildings cool?

15. Have the students rethink the experiments they have already done from the standpoint of keeping the house-box cooler. North windows will not cause the house to heat up, but they can allow a loss of the coolness of the home by heat transfer through them.

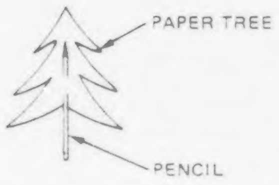
But the effect might not be so bad since the difference between the temperature inside and outside of a house is probably less in summer than in winter for many parts of the country.

16. Heat inputs to the house will be through east windows in the morning hours and through west windows in the afternoon period.

17. Pose the question, how can we stop some of the sunlight from getting into the house via the east or west windows? The discussion may be stimulated by asking about drawing shades or drapes. Show the students the piece of aluminum foil. This can be used to reflect light that shines into the window back out again. To illustrate this, shine the flashlight into the foil placed in the window cutout and observe how the light is reflected. Windows can be specially treated with so that they act like a partial mirror to reflect some of the sunlight that shines in. Many modern buildings are built with windows of this type.

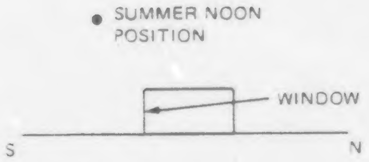
18. Have a student hold upright a pencil in front of the west window, like a thin pole just outside the window. Have the sun person rise and set. How much light did the pencil keep out of the house-box? Very little.

19. Now have a student cut out a piece of paper that would be about the right size for a tree for our house-box, and insert the pencil through it as a tree trunk.



20. Have the student now hold the "tree" in front of the window and repeat the experiment. The tree will do a good job of shading the window from the Sun. This illustrates the use of dicidueous trees. During summer the leaves will shade, but in winter the leaves fall off and allow the major portion of the sunlight to shine into the house.

21. With the window of the house-box facing south, have the sun person put the flashlight at the same approximate summer noon position used in the previous experiments. Take another smaller piece of flat cardboard, and slowly slide it over the top of the house-box as an awning or overhang until the summer noon sun is just shaded from the window.

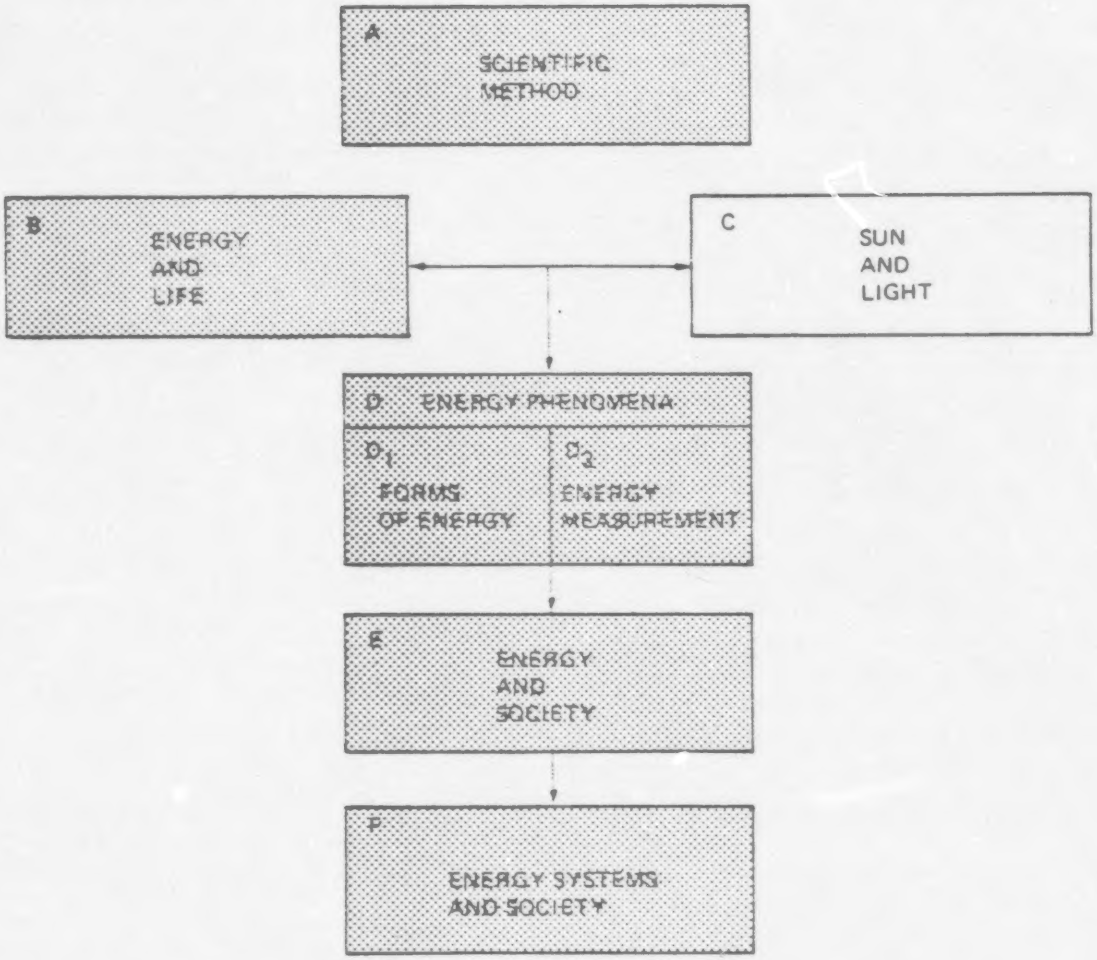


22. Now holding the overhang steady, have the sun person place the flashlight to winter noon. The light should again shine into the window. This illustrates that if an overhang or awning is correctly placed, it can shade the southern window from the summer sun, but let the winter sunlight shine in to warm the house.

The final experiments will illustrate the concept of "thermal mass", or the storing of heat or coolness.

23. Make a breadbox oven using the techniques of lesson F_V. Put nothing in it except a thermometer. Put the plastic wrap over it and put it in the sun in such a manner that you can still see the thermometer. After the temperature rises to over 100°F, take the food keeper out of the sun, but DO NOT open it. Note the time it takes to drop back down to room temperature.

24. Now repeat the experiment, but instead of an empty food keeper, put in a black painted bottle full of water. Again, put on the plastic wrap and place the thermometer in it so you can observe temperature. Put it out in the sun. It will take longer now, but again, wait until the internal temperature is over 100°F. Remove it from the sun without opening it, observe the time it takes for the interior to drop back down to room temperature. It should take longer to cool, just as it took longer to heat. Heat energy has been stored in the bottle of water. After the food keeper was taken from the sunlight, this stored heat energy kept the interior warm. This is similar to what happens in your home. The concrete slab or foundation that the house is built on, the walls, furniture, etc. all heat up during the day and tend to keep the house warmer for a while longer at night. Many solar designers will build into their houses massive walls and floors, or put large containers of water in the wall to provide extra heat storage in their homes.


A
SCIENTIFIC
METHOD
B
ENERGY
AND
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C
SUN
AND
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D
ENERGY PHENOMENA
D_1
FORMS
OF ENERGY
D_2
ENERGY
MEASUREMENT
E
ENERGY
AND
SOCIETY
F
ENERGY SYSTEMS
AND SOCIETY

SUN AS A RESOURCE

One of the problems in the use of solar energy is that it is not a constant resource. The amount of solar radiation reaching a particular area on earth depends upon the time of the year, the location on earth and the local weather conditions. The illustration below shows the geometric relationship between the sun and the earth. The earth revolves about the sun in (a nearly circular) an elliptic orbit. In the Northern Hemisphere the sun is closest to the earth during the winter time and furthest during the summer time. The question which arises is, "why is it colder in the winter than in the summer?" This question is answered by realizing that the earth is tilted to the orbit plane by about 23 degrees. Referring to Figure C-1, it may be observed that as the earth goes about in its orbit, the solar position in relation to the equator changes as a function of the season. In winter, the sun appears directly overhead when you are south of the equator, and north of the equator in summer. As a result, the sun is in the sky for a longer period of time in the Northern Hemisphere during the summer,

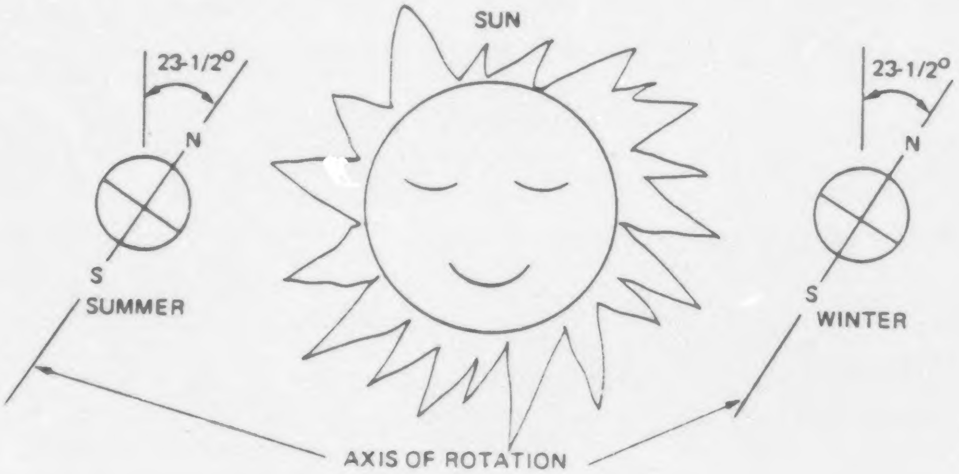


Figure C-1. Earth and Sun Geometric Relationship and therefore, we are exposed to a larger total amount of energy than in the winter time.

In the Los Angeles area, the latitude is approximately 34 degrees north. This means, if we tilt a horizontal panel toward the south at the latitude angle, it will be at right angles to the equator, (see figure C-2). If we want to collect the most solar energy over the whole year, the panel would have to be moved continuously to face the sun. However, it has been found that by fixing the panel at the latitude angle plus about 10° to 15° and facing due south we can collect enough for most purposes. In Los Angeles this would be a tilt angle of 45 to 50 degrees.

The solar energy reaching us on the surface of the earth is also controlled by the atmosphere through which it must pass. The water

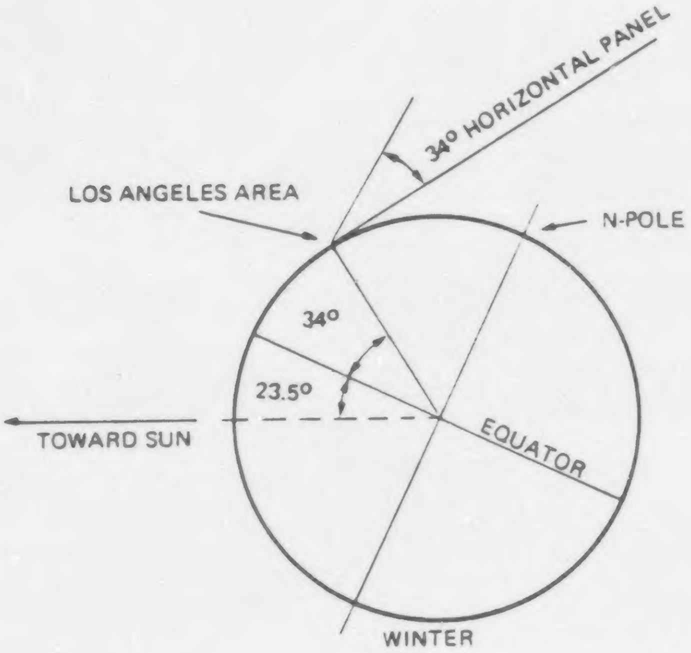


Figure C-2. Solar Panel Tilting

vapor in the air in the first 1,000 ft or so altitude affects the amount of energy reaching the surface. Water vapor is more dispersed in the afternoon than in the morning. As a result, we can obtain larger solar inputs in the afternoon time than in the morning time.

If one tries to account for all of the parameters involved, the prediction of how well a solar energy system will function can become a very complicated problem. However, in general, it is assumed that we have clear skies. Then one can refer to tables for the "insolation" (insolation refers to the amount of solar energy striking a surface area, i.e., solar flux).

THE SUN AND ITS PROPERTIES

The sun is a star around which the earth revolves. It is one of about 100 billion stars in the Milky Way galaxy. The sun is special to us because it is much closer than any other star and provides heat and light necessary for plants and animals to survive. The sun is the source of all life on earth. The next closest star to our sun is Alpha Centauri. It is 280,000 times as far from the earth as the sun. (26 trillion miles)

The sun is a very large object. It is 864,000 miles in diameter, 105 times the diameter of the earth. More than a million balls the size of the earth can fit inside of it.

The average distance from the earth to the sun is 93 million miles. Because the earth's orbit around the sun is not exactly circular, the earth will be closer to the sun in winter, 92 million miles and farther from the sun in summer, 95 million miles.

The sun lies at the center of the solar system and all planets revolve around it. The mass of the sun is also very large, 300,000 times more massive than the earth. It weighs about 2 octillion (2×10^{27}) tons.

The density of the sun varies with the depth below its surface. Density is how closely atoms are packed. At the surface of the sun its density is less than air while at the center it is more than 100 times more dense than water. The gaseous materials that make up the sun consist mainly of hydrogen.

As we know, the sun shines with its own light and gives off its own heat. We receive some of the light and heat as solar radiation. Nearly all the light and heat of the sun is emitted, or given off, by its surface. This is called the photosphere from the Greek words meaning "light" and "sphere". The average temperature of the photosphere is about 10,000 degrees Fahrenheit. This is hot enough to melt every known substance and turn them into gases. Thus, the sun consists of all gaseous material, no solid or liquid material exists on the sun. The photosphere is very active, constantly changing as gases rise and fall on its surface. Looking closely at the sun's surface, scientists have found many light dots. This appearance is called granulation and is believed to be caused by hot currents rising to the surface of the sun.

Other phenomena occurring on the sun's surface are sunspots, faculae, flocculi, prominences, flares, and the corona. Sunspots are dark roundish spots appearing on the sun's surface. They look dark only because they are not as bright as the sun surrounding them. If you could view a sunspot by itself, it would appear extremely bright. Often sunspots seem to appear in great numbers in some years and few numbers in others. About every eleven years a large number of sunspots can be seen. This pattern is called the 11-year cycle of sunspots. Astronomers think sunspots are holes in the sun's surface gases created by whirling hot gases inside the sun. The whirling action widens, cooling the gases. The cooler gases shine less brightly than the surrounding photosphere. Sunspots are also thought to be electrified and magnetic. When sunspots occur in pairs, they are opposite in magnetism.

Faculae are patches of light that appear brighter than the photosphere. They usually appear around sunspots and are believed to be rising currents of hot gas, probably the result of the same gases causing sunspots.

Like the earth, the sun also has an atmosphere. It is much less dense than the earth's atmosphere and is difficult to observe because it is hidden by the much brighter light of the photosphere. The sun's atmosphere is made up of several different layers. The chromosphere is the first layer about 9,000 miles thick. When photographed the chromosphere appears a bright reddish pink. The chromosphere is cool near the sun's surface, a little less than 10,000 degrees Fahrenheit, but as we get farther away from the sun, temperatures get as high as 36,000 degrees Fahrenheit. Astronomers also observe clouds in the chromosphere. They are called Flocculi and appear to be the upper parts of Faculae rising from the sun's surface. They are usually above or near sunspots.

Prominences are giant flames extending from the surface of the sun. They stretch out into space for more than 250,000 miles at times. The gases usually fall back into the sun in a curved path.

There is also an eruption on the sun's surface called a solar flare. A flare is not as large as a prominence and lasts only a few minutes, but it is much brighter than a prominence and explodes shooting particles out into space. Some of these particles may reach the earth and cause static on radios because they are electrified. Most particles reach the earth 20 to 40 hours after a solar flare erupts.

Above the chromosphere lies the Corona extending millions of miles into space. It is made up of electrified particles that may extend to the earth and beyond.

The source of all the sun's surface activity lies deep within the sun. Here atoms are packed so tightly together and are so hot that nuclear-fusion reaction occurs. In a nuclear-fusion reaction, the nuclei of two or more atoms join together producing a huge amount of light and heat. This occurs at around 27 million degrees Fahrenheit. The light and heat caused by the nuclear-fusion reactions occurring in the sun is the source of the sun's energy, solar energy. Only a small amount of matter in a fusion reaction produces a large amount of energy. Since the sun is very large it will keep burning for billions of years before it will run out of its nuclear fuel.

The energy produced by nuclear fusion reactions in the sun's core flows outward pressing against other atoms. This would cause the sun to fly apart except for another kind of force holding the sun together. This is the force of gravitation. It balances the forces pushing outward, keeping the sun the same size. Due to its huge mass, the sun's gravitational force is very great. It not only keeps the sun together but keeps all of the planets in their orbit as well.

Fusion reactions at the interior of the sun occur at temperatures up to 36 million degrees Fahrenheit (20 million degrees celsius). In the fusion process, hydrogen atoms are combined to form helium and the leftover mass is converted into energy.

It is estimated that only about one-half billionth of the energy given off by the sun reaches the earth. Although a very small amount reaches the earth, it is still more than sufficient to satisfy all our energy needs.

It is believed that the solar activity occurring on the sun is directly related with earth weather conditions. The eruptions of flares and electrically charged particles of the sun do have an effect on radio transmission. There exists a continuous flow of charge particles reaching the earth believed to be part of the corona, moving out in all directions. This continuous flow, unlike the sudden bursts caused by solar eruptions, is called the solar wind. Thus the sun produces energy that is both particulate radiation (electrons, protons and neutrons) and electromagnetic radiation. The particulate radiation is commonly called the "Solar Wind". The electromagnetic radiation is commonly referred to as "Solar Radiation" and it is this part of "Sunlight" that provides the light and heat for us on earth. Energy from the sun is called solar energy. In order that this energy reach earth, it must travel approximately 93 million miles. Since light travels at 3×10^8 meters/second or 186,000 miles/second it takes 8 minutes to travel from the sun to earth. Light consists of visible light which can be seen by the naked eye, and non-visible light. A large portion of light emitted by the sun lies in the visible range while smaller portions lie in invisible ranges. The spectrum of visible light can be seen using a prism (see section "How a Prism Works"). The colors of the spectrum are violet, blue, green, orange, yellow, and red. Other kinds of light that cannot be seen, but which can be felt are ultraviolet light which causes sunburns or suntans, and infra red light which becomes heat as it strikes the earth's surface.

Other types of light are radio waves which are used for communication, x-rays and gamma rays which are absorbed or reflected by the earth's atmosphere. The different forms of light energy that we have discussed can be described by their wavelengths or frequencies. Light in the x-ray or gamma ray range have high frequencies or short wavelengths. Light in the radio wave range have low frequency or long wavelengths. Frequency is usually measured in "hertz" (cycles/sec) and wavelengths are usually measured in centimeters or "Angstroms" (an angstrom is 1×10^{-8} cm). All light is called the electromagnetic spectrum.

Heat is caused by infrared radiation as it strikes the earth's surface. This heat cannot leave the earth's atmosphere easily, becomes trapped by the atmosphere and warms the earth. Thus, two basic necessary forms of energy reach the earth; heat and light.

The hot gaseous materials that make up the sun consist mainly of hydrogen.

THE SUN AND ASTRONOMICAL RELATIONSHIPS

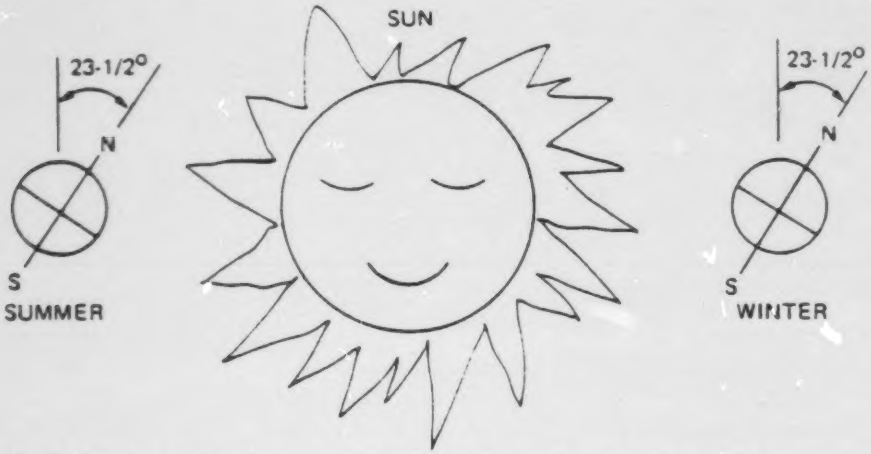
Student Reader (4th - 6th)

We know that the sun is a star contained in the Milky Way galaxy. But why does it seem to shine so much brighter than other stars? How big is the sun? What causes the earth to be colder in winter than in summer?

To begin with, let's think about the size of the sun. How big is it? It turns out that the sun is more than 100 times as wide as the earth and more than a million earths can fit inside of it. If we imagine that the earth is the size of a marble, then the sun would be 4½ feet across, a very large object indeed. Imagine having a marble that size!

We also know that the earth is about 93 million miles from the sun, which seems like a very long ways. But compared to the next nearest star, Proxima Centauri, this distance is really very short. Proxima Centauri lies more than 26 trillion miles away from Earth or 280,000 time farther than the distance to our sun. This explains why it is not as bright as the sun. If we stood one inch away from a lamp representing our sun, then the next nearest lamp, representing our nearest star would be 4.4 miles away, and therefore, far more light is received from our sun than any star.

The earth rotates about its North-South pole axis, and it completes one full rotation in 24 hours. The earth not only rotates on an axis, but it also revolves around the sun. One complete revolution, which takes 365¼ days, is called a year. Although the earth's rotation explains day and night, it does not explain seasonal changes like winter, spring, summer and fall. Seasonal changes occur due to the earth's tilt.



The North Pole is tilted at a 23½ degree angle toward the sun in summer and 23½ degrees away from it in winter. In summer, the sun appears higher in the sky and it stays out longer. In winter, the sun appears lower in the sky and stays out for a shorter period of time. The sun gives us more heat in the summer than in winter because it is out for a longer period of time. This causes seasonal changes.

We have said that the sun is about 93 million miles away. This is only an average value. The earth actually revolves around the sun along an elliptical or oblong path. It is closest to the sun during winter at 92 million miles and farthest from it during summer at 95 million miles.*

We can now review what we have learned about the sun and us. The sun is more than 100 times as wide as the earth and more than a million earths can fit inside it. The earth rotates in 24 hour intervals (day) on a North-South pole axis at a 23½ degree tilt. It also revolves around the sun completing one revolution in 365¼ days (1 year). The earth's tilt causes seasonal changes. The earth is closest to the sun during winter, 92 million miles; and farthest from it during summer, 94 million miles. The closest star to the sun, Proxima Centauri, lies more than 26 trillion miles from earth; 280,000 times the distance from the earth to the sun.

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*The sun is actually most intense in winter, but since the length of the day is shorter in the Northern Hemisphere we do not get as large total amount of solar energy, as we would in Summer.

Two basic physical properties of the sun are heat and light. Heat is a form of energy that may be transmitted to the Earth from the sun by radiation. This radiation occurs as "light". Light travels as a wave in the same way as sound and water waves. Light travels at the speed of 3.00×10^8 meters/second or 186,000 miles/second. This is much faster than any sound or water wave. Light waves are called electromagnetic. Like sound waves, light travels at different notes called frequencies. Likewise, since not all sound can be heard by humans, not all light can be seen. Both visible and non-visible light is emitted by the sun. These different notes or frequencies of light are known as the electromagnetic spectrum. The visible spectrum consists of light (colors) that we see. A much larger portion of light is in the invisible spectrum. They are radio waves, infrared, ultraviolet, x-rays, and gamma rays. Much of the light that the sun radiates is in the visible range.

Not all light that the sun radiates approaches the Earth. The sun radiates light in all directions and this light must also travel 93 million miles to reach the Earth. Much of the light that finally reaches the Earth is either reflected (reradiated) or absorbed by the Earth's atmosphere before it reaches the surface of the Earth. Although all of the light radiated from the sun does not reach the Earth, it is still sufficient to make plants grow, to bring daytime and to warm the atmosphere.

The spectrum of visible light is violet, blue, green, yellow, orange, and red.

1. The Sun:

   333,000 more massive than Earth

   93 million miles from Earth

   100 times as wide as the Earth

2. The Earth:

   7900 miles wide (diameter)

   Mass = 1.32×10^{25} pounds = 6,600,000,000 Trillion Tons

   Period of rotation = 1 day (24 hours)

   Period of 1 revolution = year (365 days)

The Solar System:

9 Planets (Name)	Relative Radius $\left(\frac{\text{Planet Radius}}{\text{Earth Radius}}\right)$	Distance from the Sun (Miles)
Mercury	0.4	36.0 million
Venus	0.95	67.3 million
Earth	1.0	93.0 million
Mars	0.53	142 million
Jupiter	11.2	484 million
Saturn	9.4	887 million
Uranus	4.2	1784 million
Neptune	4.0	2795 million
Pluto	0.5	3664 million

HOW A PRISM WORKS

WHAT CAUSES RAINBOWS?

Why do we see rainbows only after it rains and not just anytime? Rainbows are caused by the spreading of sunlight (as it passes through rain droplets) into different colors which reflect into our eyes. This explains why we only see rainbows after it rains when the sun is out. The separating of sunlight showing different colors is called a spectrum. A rainbow shows the spectrum of visible light. Have you ever seen a rainbow? If not, we can make our own rainbow by using a prism. A prism can produce the beauty of a rainbow much in the same way as it occurs naturally. A prism spreads light into different colors of the visible spectrum. As light travels from one media to another, such as from air to glass, it is bent. Of course light cannot go through a wall or glass unless it is transparent. Also, some colors of light bend more than others and thus a spectrum of the different colors of visible light can be seen. A prism showing how light is bent into different colors is shown in Figure C-3.

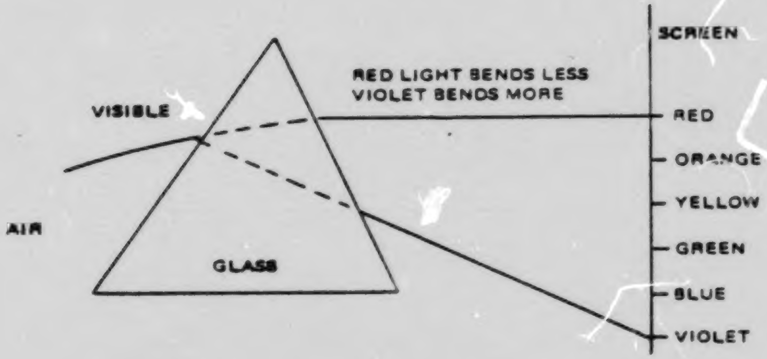


Figure C-3. Prism and Color Spectrum

There is also a much wider spectrum of light that we cannot see. Infrared, which lies above the red end of the spectrum, gives us heat. Ultraviolet light, which lies below the violet light, gives us tans (or sunburns, if we stay in the sun too long).

It is not necessary to have a prism to see different colors of light. Anything transparent may break light into different colors. A clear bottle filled with water may show different colors of light if you look closely.

PHYSICAL PROPERTIES OF THE SUN

Unit C_K (Approximate Grade Level #K)

OVERVIEW

Through the use of the Greek myth of Daedalus and Icares, a guided fantasy which personalizes the myth, and a simple experiment which establishes the idea of the sun melting wax as a real thing, the students are exposed to the idea that the sun is a source of heat energy.

LEARNING OBJECTIVE

Kindergarten students will demonstrate an awareness that the sun is a source of heat energy through participation in (1) hearing a story, (2) acting out a guided fantasy, and (3) observing an experiment.

EVALUATION

This objective will be evaluated by teacher observations which are recorded on the participation-observation record sheets.

SPECIAL MATERIALS

- Candle and black paper
- A copy of the story of Daedalus and Icarus
- The Flying Fantasy

VOCABULARY

Sun, energy, heat

EXTENSION EXERCISES

- The class can measure the temperature in both the sun and the shade. (See lesson D_{KI})

- The class can explore the relationship between the earth and the sun (See lesson B_I).

- The class can learn that light can be bounced and bent (reflected and refracted). (See lesson A_{II}, and choose a small portion of what is there to explore with your class.)

LESSON PLAN

1. The class is read or told the story of Icares and Daedalus. Teachers should note that this is a "real" Greek myth, created sometime B.C.E. For a more detailed version, you can check any source of Greek myths, this version of the story emphasizes the sun and solar energy.

This story is a myth originating from Greek culture in ancient times (early B.C.). Its objective is to have students (and teachers) realize that the sun is an unnoticed, but important part of our lives. Along these lines, the author emphasizes the sun and solar energy.

A very long time ago, during the age when Greek art and science was well known lived a most skillful artist and scientist. His name was Daedalus. Daedalus could do great things and often built things that used energy from the sun. His son, Icares, was a student who also studied the sun. Icares hoped to learn much about the sun from his father.

One day, Daedalus was ordered by his King to build a great maze from which no one could escape. Daedalus did this, and the

King was very pleased. However, soon after the maze was built, Daedalus fell out of favor with the King. The King feared that Daedalus would try to take over the throne. The King threw Daedalus and his son, Icares, into the maze, hoping they would never be able to find their way out.

Icares asked his father, "Father, can you find our way out of this maze?" Daedalus answered him, "Icares, I made this maze so well, not even I can find my way out."

The two men sat down thinking this was the end. How would they ever be able to get out of the maze? Then, Daedalus had an idea. He jumped up and said, "I know how we can get out."

We do not have the tools to dig under the maze and make a tunnel to escape but we do have wax from our candles and leaves from the bushes. With this, we can build wings and fly over the walls of the maze to safety!"

Icares was excited by his father and could hardly wait to start building his wings, "But Father," he said, "How can we use the wax and leaves to build wings?"

His father, Daedalus, answered him, "Using these mirrors that I have hidden from the guards, we can melt the wax for our wings. In the middle of the day, when the sun is highest in the sky, we can reflect the sunlight on to the wax from all of our mirrors. When the wax gets hot enough, we can put the leaves into it, forming them into wings. Over night, the wax will cool and become hard and in the morning, we will be able to fly."

So Daedalus and his son melted the wax that day; made their wings and waited overnight when the sun was not out, for the wax to cool. The next morning, they were ready. Just before leaving, Daedalus told his son to be careful not to fly to close to the sun.

For if he flew too close, the heat of the sun would again make the wax soft. If this happened, his wings would fall apart and he would drop into the sea.

Icares agreed with his father. "I will fly close by your side." Off the two flew out of the trap, over the walls and safely onto the ocean. But they were not free yet. They must still travel a long distance over the sea until they would reach land again. Along the way, the wind began to blow on Icares, who was much lighter than his father. The wind made him fly higher and higher, although he tried to keep close to his father's side. Closer and closer he flew to the sun. Soon the sun's energy became stronger and stronger, and the wax on his wings began to melt. Suddenly, the wax became so soft and the leaves dropped away. Icares could not fly anymore and fell into the sea. Sadly crying, his father, Daedalus, continued on across, flying to freedom. The sea is now named in honor of Icares and is called Icaream sea.

2. After the story, or at a later time, the class should be engaged in the guided fantasy for example, see Flying Fantasy attached. If you haven't worked with fantasies in your classroom (1) the following procedure is suggested; (2) You may want to check out Put Your Mother on the Ceiling, Children's Imagination Games, The Viking Press, New York, 1973.

A. Ask the class, "How many of you day dream?" You may want to talk about daydreams.

B. Tell them that all of us are going to share a daydream together.

C. Have the class draw conclusions about whether the sun gives off heat energy. Ask them to invent ways of making the candle melt faster.

FLYING FANTASY

Imagine that you are going to make a pair of wings ... you take 2 broomsticks ... you take two feather pillows and you take two candles ... you shake open the feather pillows and spread out the feathers over the broom sticks ... you then light the candle and melt the wax to glue the feathers in place ... then you put on your wings and go up on to the roof ... you walk very carefully to the edge ... you stand there for a moment and look down ... it is a long way down, and you are a little scared ...

You gather up all your courage ... bend your knees ... flap your wings a little bit ... and jump off the edge ... all of a sudden you are flying ... enjoy it.

You feel the wind rush past your face ... you swoop down past your house ... and then soar up high over your neighborhood ... get yourself ready ... we are going to do a loop-de-loop, ready ... go ... can you do another ...?

You decide to fly higher and higher ... you go up and up ... you fly through one cloud and then another ... you can hardly see the ground anymore ... you begin to feel the warmth of the sun ... it feels good ... you turn over and fly on your back ... letting the sun warm your stomach ... you decide to fly even higher, so you turn over and fly up again ... the sun feels hot on your wings ... you begin to worry that the wax might melt ... so all of a sudden you dive.

You are falling towards the ground ... you are diving and the ground is rushing up, you put out your wings ... and swoop over the hills...

... you see a tunnel up ahead ... you decide to fly through the tunnel ... it is dark and cool in the tunnel ... can you feel it ... then you burst out into the sunlight again.

It is almost time to go back home ... you fly up and do one more loop-de-loop ... then fly back over your neighborhood ... gently you glide down and land on your roof ... you take off your wings and go inside ...

When you are ready ... open your eyes and come back to this room.

(Afterwards, you may want to remind the class, that people can fly in stories and in daydreams, but not in real life.)

SUN - EARTH RELATIONSHIPS

Unit C_I (Approximate Grade Level #1)

OVERVIEW

The students will review the concept that the sun is a source of Energy (heat) by reviewing (or covering for the first time) the exercises in Lesson B_V, and through subsequent work on the playground. Then in the classroom, they will explore the physical relationships between the earth and the sun, and how we get day and night. The lesson concludes with the students "mapping" in a picture, these solar relationships.

LEARNING OBJECTIVES

Students will demonstrate knowledge of the astronomical relationships between the earth and the sun (distance, size, rotation, revolution) through either (1) physical manipulation of models as observed by the teacher. or (2) drawing a picture which reflects an understanding of the system.

EVALUATION

Evaluation of this objective can take place either through (1) analysis of drawings done by the students, or (2) observation of their manipulation of balls which represent the elements we are considering in the solar system.

SPECIAL MATERIALS

- A flash light or projector
- Paper and crayons, etc.

VOCABULARY

Sun, earth, energy, rotate (revolve)

EXTENSION EXERCISES

- The class can add the moon to their perception of the solar system.

- The class can make a full solar system showing all the planets, etc.

- The class can move on to lessons D_{2I} and measure the differences between the temperature in the sun and in the shade.

The class can move on to portions of lesson A.II and learn something about the light which comes from the sun.

LESSON PLAN

1. It will be necessary to review (or establish for the first time) the insights developed in lesson C_K. It would be well to teach or reteach that lesson prior to beginning this lesson.

2. Take the class out to the playground, have them stand in the sun, and ask them how warm they feel. Take them in the shade, and ask the same question. See if all places in the sun, and all places in the shade feel the same. Discuss why they feel warmer in the sun. (Answer: The sun gives us heat energy.)

3. Inside your classroom, with the windows darkened and the lights off (if possible), build a human version of the solar system.

    a. Have a student stand in the middle and be the sun. Give the student a flash light.

   - b. Have a second student be the earth. Have the student shine the light on the student's stomach. Ask everyone if it is day or night on the earth's stomach (or bellie button). What about on the earth's back?

   - c. Have the earth rotate (turn around) and discuss when it is day, and when it is night.

   - d. Have the earth revolve around the sun at the same time it is revolving.

   - e. If you want, you can add in the moon, and talk about its cycles at the same time.

4. After you have done this with the whole class, break the class into pairs (or 3's if you have added the moon). Have one be the sun, one the earth, and one the moon and have them "act out how this all works.

5. Have the class draw pictures of the whole system. (If you have reviewed lesson A_K, it might be nice for them to include a picture of them flying as part of the solar system).

6. You can also have them use various sized rubber balls, or styrefoam balls, etc./to represent the elements in the solar system.

PHYSICAL PROPERTIES OF THE SUN

Unit C_I (Approximate Grade Level #1)

OVERVIEW

Through measuring the heat and the light given off by the sun over an extended period of time, the students will reinforce their knowledge that the sun is the source of these two kinds of energy. Rather than creating a new lesson for this objective, this will be achieved in conjunction with our measuring objective for the first grade — lesson $(D_2)_I$.

LEARNING OBJECTIVE

The students will demonstrate knowledge that the ability of the sun to give off heat and light are physical properties. They should participate in the measurement of these properties and list two of the associated phyiscal products.

EVALUATION

Lesson $(D_2)_I$ will serve two functions: (1) Teaching about measurement, and (2) teaching about the physical properties of the sun. The measurement sheets will reflect an understanding of the task of measurement, response to the question: "What kinds of energy does the sun give off?" will evaluate our task in this objective. Every student should be able to list: heat and light.

Turn to Lesson $(D_2)_I$.

SOME SPECIAL PROPERTIES OF LIGHT

Unit C_{II} (Approximate Grade Level #2)

OVERVIEW

The students will come to understand that light can be both "bounced" and "bent". Through this lesson we will introduce the concept of reflection as the bouncing of light, and refraction as the bending of light. The students will be exposed to a series of demonstrations of the bending and bouncing of light, they will have an opportunity to "play" with light (reflecting and refracting it) and will then demonstrate their understanding of these concepts either through (1) a written worksheet which identifies models as either reflecting or refracting, or through (2) designing a system of lenses, mirrors and prisms which gets the light from one point to another. (See write-up on How Prism Works.)

OBJECTIVE

The student will demonstrate a knowledge that light can be reflected and refracted, after participating in a series of demonstrations and experiences, through either a written worksheet or an original "blue print."

EVALUATION

The lesson exposes the student to a series of demonstrations of the concept that light can be both bounced and bent. We are concerned that (1) the student grasps the fact that light can be both bent and bounced, and that (2) the student assimilates the vocabulary REFLECT and REFRACT to identify these concepts. There are two separate evaluation modes offered:

A. The worksheet is on the comprehension level, and asks the student to label given examples as being either reflection or refraction.

B. The light puzzle asks the student to demonstrate an application of these understandings by combining given elements (mirrors, oval lenses) to have the light come out of the box "the right way". In doing so, we also ask the student to label each point of reflection and refraction.

SPECIAL MATERIALS

- A large clear container full of water/a ruler or stick
- Mirrors (hand-sized)
- Lenses (magnifying glasses, etc.)
- A large clear glass pop bottle
- Worksheet or light puzzle (included) Figure C-4
- Thin metal bar
- "Pinky" rubber ball

LESSON PLAN

1. Bounce a ball in the classroom. Ask the students if they can do the same thing with light?

2. Pass out some mirrors, and use a light source and bounce light around the room. See if you can play catch with light, and bounce it two three or more times.

3. Have the teacher bend a thick metal rod. Ask the students if they can do the same thing with light?

4. Show the demonstration of the ruler in the class of water (and how the ruler seems to "break" at the water level. And discuss how the light was "slowed" by the water, and so it was bent.

5. Pass out magnifying glasses. Let the kids project a point of light from the source onto a piece of paper. Discuss the idea of a focus. This is the point where the light entering the lense is all bent together.

6. Draw diagrams of a concave and a convex mirror, a concave and a convex lense. See if the students can figure out what each will do the light (or use a worksheet).

7. Review the concepts:

   - Define Bounding as Reflection
   - Define Bending as Refraction

8. Pass out worksheet or light puzzle. (See Figure C-4.)

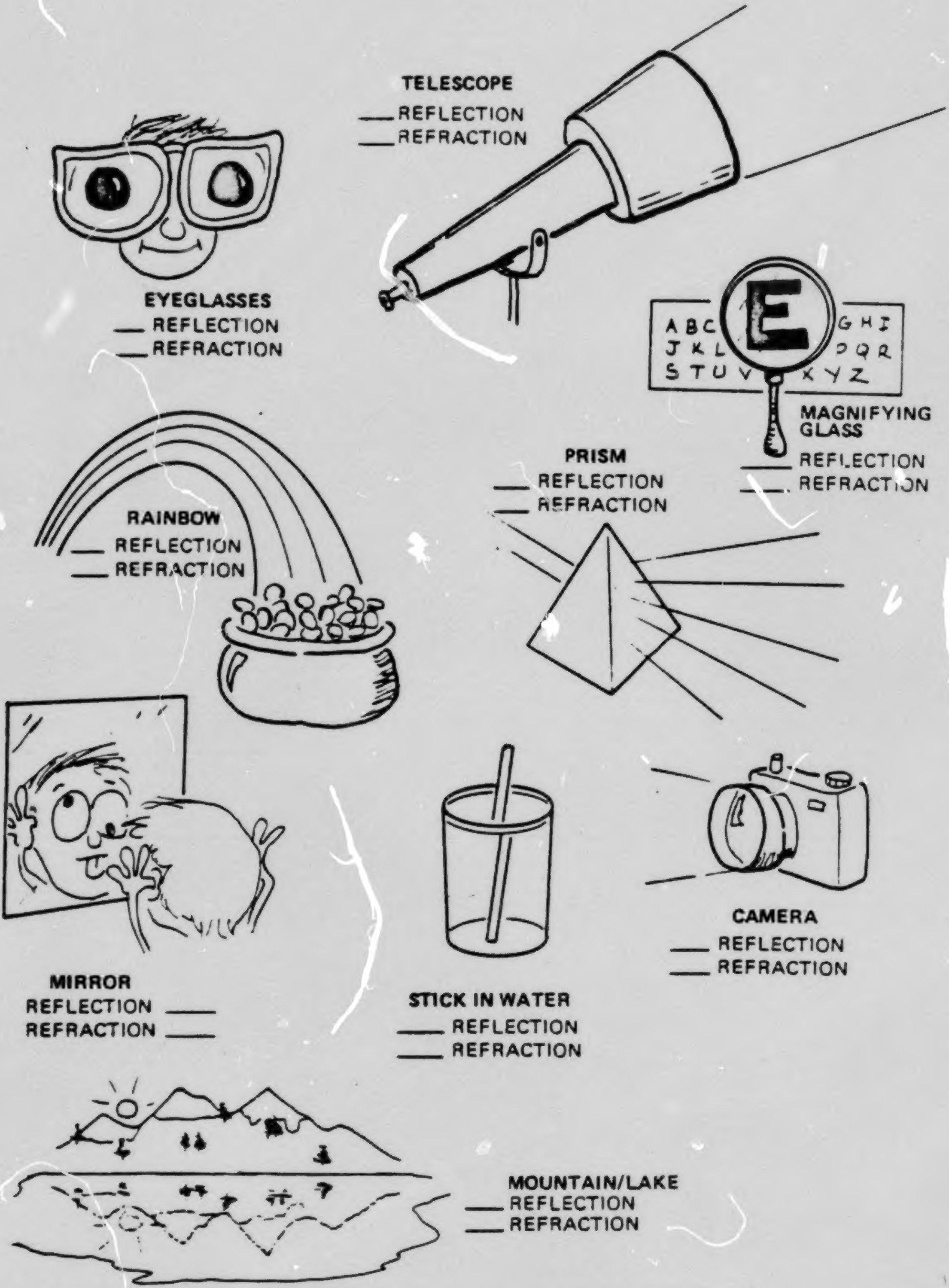

TELESCOPE
___ REFLECTION
___ REFRACTION
EYEGLASSES
___ REFLECTION
___ REFRACTION
ABC GHI
JKL PQR
STUV XYZ
E
MAGNIFYING GLASS
___ REFLECTION
___ REFRACTION
PRISM
___ REFLECTION
___ REFRACTION
RAINBOW
___ REFLECTION
___ REFRACTION
CAMERA
___ REFLECTION
___ REFRACTION
MIRROR
REFLECTION ___
REFRACTION ___
STICK IN WATER
___ REFLECTION
___ REFRACTION
MOUNTAIN/LAKE
___ REFLECTION
___ REFRACTION

Figure C-4. Reflection and Refraction Sample Worksheet

THE SUN, EARTH, AND LIGHT

Unit C_{III} (Approximate Grade Level #3)

OVERVIEW

Students construct as a project, a color wheel. They are shown that colors may blend together to appear whitish. This study further delves into the use of a simple prism so that the students can see how white light can be broken up into the colors of the spectrum. Then a drawing of the spectrum is made.

LEARNING OBJECTIVES

The students will demonstrate understanding that light is composed of many colors and that in full combination, these colors appear white, through participation in class activities.

EVALUATION

Evaluation of this objective will be indicated by successful drawing of a light spectrum.

MATERIALS

- A piece of heavy white cardboard or poster board at least 4 inches square.
- A length of string or a heavy thread, about 3½ ft long.
- A simple prism for experimentation with light
- A light source.

VOCABULARY

Spectrum, colors, prism

LESSON PLAN

1. Take a piece of white cardboard, and using a pencil compass, draw a circle about 3 inches in diameter.

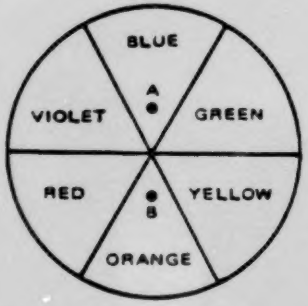
   Do not change the compass setting. "Walk the compass" or mark off equal distances around the circle perimeter.

   Draw a straight line from the center of the circle to each of the marks so that the circle is divided into 6 pie shape pieces.

   Using crayon, color pencils, or water colors, color the circle in the following way: Paint one of the pie shape pieces red, then working your way around the circle in a clockwise fashion, paint the next 5 pie shapes in the following sequence: violet, blue, green, yellow and orange (See figure in Item 2).

2. Now cut the disk out of the cardboard.

   Make two small holes near the center about ½ inch apart. (See point A and point B on the following drawing.)



   Put the string or thread through the two holes.

   Tie the two ends together and hold the string by the loops at each end.

Have someone slide the color disk to the center of the string.

Whirl the disk around until the string is tightly twisted.

Now gently pull on the loops back and forth so that the disk spins quickly.

3. Look at the color side. Do you see many colors? What colors do you see? The colors should blend together, making the cardboard circle appear whitish. The colors should appear and disappear as the disc slows down or speeds up.

4. Take the prism, and using either the sunlight from outside or beam of light from a slide projector. Develop the color spectrum against a wall or cardboard.

5. Have the students make color drawings of the spectrum that they see. Off of the blue end of the spectrum, have the students write ultra-violet, meaning the deep blue colors that their eye cannot see, but nevertheless are there.

SPECIAL NOTES

A further adaptation of the prism experiment can be to use a second prism. Have the light of the first prism make the spectra with the second prism close by recombining the spectra to form white light once again. This experiment was actually done by Issac Newton, 1672, when he proved that white light was the coalescence of many colors.

THE SUN, EARTH, AND SEASONS

Unit C_{IV} (Approximate Grade Level #4)

OVERVIEW

By shining a flashlight at different angles, at the same distance from a piece of paper on the floor, students learn how a direct beam of light has greater concentration than ones striking the floor at an oblique angle. This can be used to explain why the earth is warmer in summer than in winter, although the earth is furthest from the sun during summer. Using a bare small wattage lamp and a globe, students further experiment to see the concepts of night and day and the seasons.

LEARNING OBJECTIVES

The students through a series of simple experiments, study the geometric relationship between the earth and the sun. These experiments will be used to illustrate why the earth is warmer at the equator than the poles, why the earth has seasons, and why the earth is warmer in the northern hemisphere during summer than winter.

EVALUATION

The students will demonstrate a knowledge of the concept of the earth's tilt to orbit plane with the sun. The students will also comprehend the relationship of the earth's tilt with the production of seasons on the earth.

SPECIAL MATERIALS

- A small flashlight
- A piece of string 4 or 5 ft long
- A large sheet of paper

- A lamp without a shade with a small lightbulb
- A small globe (preferably a globe of the earth)

VOCABULARY

Orbit, Orbit Plane, Rotation, Seasons, Diurnal, Revolution

LESSON PLAN

The teacher will pose the question, "Why does the earth have a day and night?" (The earth rotates in and out of the sun's rays.) The next question, "When is the earth closest to the sun; during winter or during summer?" (The earth is closest to the sun during the winter time.) Once this question is answered, a third question will be asked, "Why then is the earth warmer during the summer than the winter?" The teacher will propose a series of experiments to investigate these questions and experimentally determine the answers.

Take a reasonably large piece of paper (1½ x 11 or larger) and tape it to the floor.

2. Take one end of the string and tie it around the flashlight, close to the lighted end.

3. Take the other end of the string and tape it or tack it securely to the center of th piece of paper on the floor.

   NOTE: The exact length of the string will depend on the size of the students. The student should be able to hold the flashlight with the string slightly taut directly above the page.

4. Have a student or students hold the flashlight directly over the page with string stretched taut (not so tight as to pull it loose from the paper).

5 Have another student with a crayon draw the approximate outline of the lighted circle on the paper (it may be necessary to darken the classroom).

NOTE: This experiment may be done by several students at one time using different flashlights and different pieces of paper.

6. Now have the student with the flashlight move the flashlight 2 or 3 ft off of the straight up and down position while maintaining the string in a taut position (to insure that the flashlight remains the same distance from the paper).

7. While the student holds the flashlight steady, have another student, using a different color crayon, draw the outline of the lighted spot on the page.

Question which spot is now bigger?

8. Have the student move the flashlight still further away from the vertical position and have the other student, again using a different color crayon, draw the outline of the light.

9. Have the students measure the dimensions of the spots that were drawn on the page.

10 Compare the sizes of the spots with the positions of the flashlight.

11. Also have the students compare the brightness of the different spots of the light in relation to their size, i.e., was the light on the page brighter when the flashlight was straight overhead or was it brighter when the flashlight was tipped to an angle?

COMMENT: The amount of light energy coming from the flashlight remains constant during the experiment. Therefore, if the light is spread over a larger area, there must then be less light energy per square inch on the larger spot than on the smaller spot.

12. Use this experiment to tell the students that during the summer time, the sunlight shines more directly overhead than during the winter time. Therefore, that portion of the earth receives more energy per unit area during summer than it does during winter (the sun angle is greater to the surface of the earth, therefore, the sun's energy is spread out over a wider area). This explains why the earth is warmer during the summer although the sun is actually further away than in winter time.

13. Place the lamp without a shade and with the low wattage bulb, on a table.

14. Take a world globe and put it several feet from the lamp.

15. Darken the room.

16. Have the students observe how the light shines on the globe. Can they see how there is a day and night time?

17. Take the globe and put it in a position so that the globe is tilted in such a way that the North Pole points to the light. This will

simulate what season? (During the summer time, the sun is higher in the northern hemisphere's sky.)

18. Have the students discuss the concepts of the seasons.

19. What season is this in the southern hemisphere?

20. The students can rotate the globe at various tilt angles; i.e., with the North Pole facing toward the lamp, away from the lamp and in various other directions. Have the students identify the season related to the position of the earth in each case.

SPECIAL NOTES

An adaptation of the experiment could be for students to hold a flashlight in a horizontal position. Then using small cards, have the students first hold the card in a flat position (so that flashlight shines on the edge of the card) and then slowly have the students rotate the card toward the light. As they do this, have them observe how bright the light on the card is. This experiment shows why solar collectors are tilted up from the roofs toward the south so that they may obtain the maximum solar intensity upon them.

MORE ABOUT THE SUN AND EARTH

Unit C_V (Approximate Grade Level #5)

OVERVIEW

Students will conduct independent study via the library or other research books to enable them to draw detailed pictures of the sun and its characteristics, and/or write a report about the sun, its features, and how they affect the earth.

LEARNING OBJECTIVES

The students increase their knowledge of the various features of the sun and the interaction of the sun with the earth.

EVALUATION

The students will be able to identify at least two special features of the sun, (e.g., sun spot. prominences, solar wind, etc.). Students will also be able to identify interactions on the earth (effects on weather, effects on radio transmission, effects on tides, etc.).

SPECIAL MATERIALS

- No special materials are required for this lesson.

VOCABULARY

Photosphere, Sunspots, Corona, Flares, Prominences, Solar Wind, Chromosphere.

LESSON PLAN

At the discretion of the teacher, this assignment can be made individually or for small teams of students. The students will be requested to carry out a library search to find out features about the sun.

1. This lesson is left largely to the discretion of the teacher and the evaluation of the most effective form of lesson for the particular group of students.

2. The lesson is basically to obtain a better understanding of the various features of the sun such as sunspots, the various forms of atmosphere around the sun, how the sun derives its energy through thermo-nuclear reactions, etc.

3. Class assignments can be given on an individual or group basis.

4. The students can prepare such items as small individual drawings of the sun showing sunspots, prominences, etc.; a large mural type painting made by groups of students showing the same characteristics, or small essays or extensive reports discussing the sun.

SPECIAL NOTES

This lesson will not only increase the understanding of the sun by the students, but can also be used to develop further the library skills and individual study capabilities of the students.

THE SUN, EARTH AND OTHER PLANETS

Unit C_{VI} (Approximate Grade Level #6)

OVERVIEW

Students are shown a slide presentation of the space mission of "Viking". Viking was an unmanned probe sent to the planet Mars. The slides with pre-recorded cassette tape commentary explained to the students the mission and about conditions on the planet Mars. Students are then asked to pretend that they are space travelers on the planet Mars and to examine how a solar hot water heating system would operate in the much weaker solar conditions of the "red planet".

LEARNING OBJECTIVES

Students further increase their understanding of the interaction of the sun and earth. This is accomplished by having the students carry out investigations of solar conditions on the planet Mars, and comparing these results to Earth.

SPECIAL MATERIALS

- A special 40 slide set of the "Viking Mission", with cassette commentary.

VOCABULARY

Isolation, Solar Intensity, "Inverse Square Law"

LESSON PLAN

The teacher will ask the students if they would like to go to the planet Mars. After some discussions, the teacher will ask the students if they have heard of the "Project Viking". The Viking Mission was an unmanned space program to martian study the environment. Landers were sent to the surface of Mars to study the local weather conditions, send back color television pictures, and to carry out experiments to determine if in the locations of the landing there were any life.forms.

1. Using the set of 40 slides and the pre-recorded cassette tape commentary, carry out a lesson illustrating to the students about the mission to Mars.

2. Conduct a general discussion with the students in relation to the slides they have seen.

3. Tell the students that they are now going to pretend that they are astronauts and will be helping to set up a Mars colony.

4. Ask the students if they can use solar energy to heat their water on the planet Mars (their answer should be yes).

5. Ask the students if the insolation (that is the amount of sunlight falling on the ground) will be more or less than on earth. Why?

The further away you are from the source of energy, the less energy you will receive. Since we know the amount of solar energy falling on the earth, we can use a simple relationship to calculate the solar energy present at the distance of Mars. We use what is known as the "inverse square relationship". By "inverse square", we mean that if we were to get on a space ship and at a point in space twice as far away from the sun as the Earth is in its orbit, we would receive only 1/4 the intensity of the sun. That is, we did not divide the amount of sunlight on earth by 2, but rather by 2 x 2 (i.e., 2^2). If we go out in space 3 times as far from the sun as the Earth is in its orbit, we receive 1/9 of the amount sunlight we receive on earth.

The following is a short table illustrating the differences between Mars and Earth.

	MARS		EARTH	
MEAN DIAMETER	4,210 (mi)	6,775 (km)	7,918 (mi)	12,742 (km
MEAN DISTANCE FROM SUN	141,636,000 (mi)	227,941,000 (km)	92,957,000 (mi)	149,600,000 (km
MAXIMUM DISTANCE FROM SUN	154,862,000 (mi)	249,226,000 (km)	94,510,000 (mi)	152,100,000 km
MINIMUM DISTANCE FROM SUN	128,410,000 (mi)	206,656,000 (km)	91,404,000 (mi)	147,100,000 (km
TILT OF EQUATOR TO ORBIT	25.2°		23.5°	
LENGTH OF DAY (Earth Clock)	24 hours; 39 minutes		24 hours; 0 minutes	

1. As an exercise, let the students make some comparative observations and numerical calculations comparing Earth with Mars.

2. Pose the question, "If we have a solar heating system for our water here on Earth that works well, approximately how much bigger or smaller would the solar panel have to be at a space station on Mars in order to have our water heated just about the same?" Tell the students that all they must do to initially estimate this is to compare the differences between the distance of the Sun from Mars

with the distance of the Sun with Earth. The following is an example of how to do this calculation. The difference will be as the square of the distances from the Sun. We will do the problem in units of the Earth-Sun distance (called by astronomers an "astronomical unit" or a.u.) then

$$1 \text{ a.u.} = 92{,}957{,}000 \text{ miles} = 149{,}600{,}000 \text{ km}$$

So the Mars distance from the Sun, in astronomical units is

$$141{,}636{,}000 \div 92{,}957{,}000 = 1.52 \text{ a.u.}$$

Then, the panel size at Mars, if proportional to the square of the distance from the Sun or size on Mars = $(1.52)^2$ size on Earth.

$$\frac{1^2}{(1.52)^2} = \frac{\text{size on Earth}}{\text{size on Mars}}$$

If our panel was 40 ft^2 on Earth, on Mars it would be $(1.52)^2$ bigger, or

$$92.4 \text{ ft}^2 \; [(1.52)^2 = 2.31].$$

3. As can be seen from the calculation, a solar panel more than twice as big, will be required for the solar system to operate on Mars. The main problem perhaps with such a system on Mars is the lack of water — i.e., our solar system might be fine, but we will have very little fluid to heat with it! Another interesting feature, when thinking about solar applications on Mars, is that the planet has much less atmosphere than does Earth. On Earth, the atmosphere tends to attenuate or scatter the light coming from the Sun. This problem would not be nearly as great on the planet Mars.

4. Another interesting calculation that the students can make is the following:

- Using the minimum distance of both the Earth and Mars from the sun as a yard stick, have the students determine the variation in solar energy present during different times of an Earth and Mars year.

EARTH — minimum distance in a.u. = 91,404,000 ÷ 92,957,000 = 0.98

maximum distance in a.u. = 94,510,000 ÷ 92,957,000 = 1.02

Then using the "inverse square" relationship

$$\frac{(0.98)^2}{(1.02)^2} = \frac{\text{minimum distance energy}}{\text{maximum distance energy}} = \frac{0.96}{1.04}$$

0.96 goes into 1.04, 1.08 times; so when the Earth is closest to the sun, the solar energy present at the Earth is only 1.08 times that when the Earth is furthest away from the Sun.

MARS — minimum distance in a.u. = 128,410,000 ÷ 92,957,000 = 1.38

maximum distance in a.u. = 154,862,000 ÷ 92,957,000 = 1.67

Then using the "inverse square" relationship

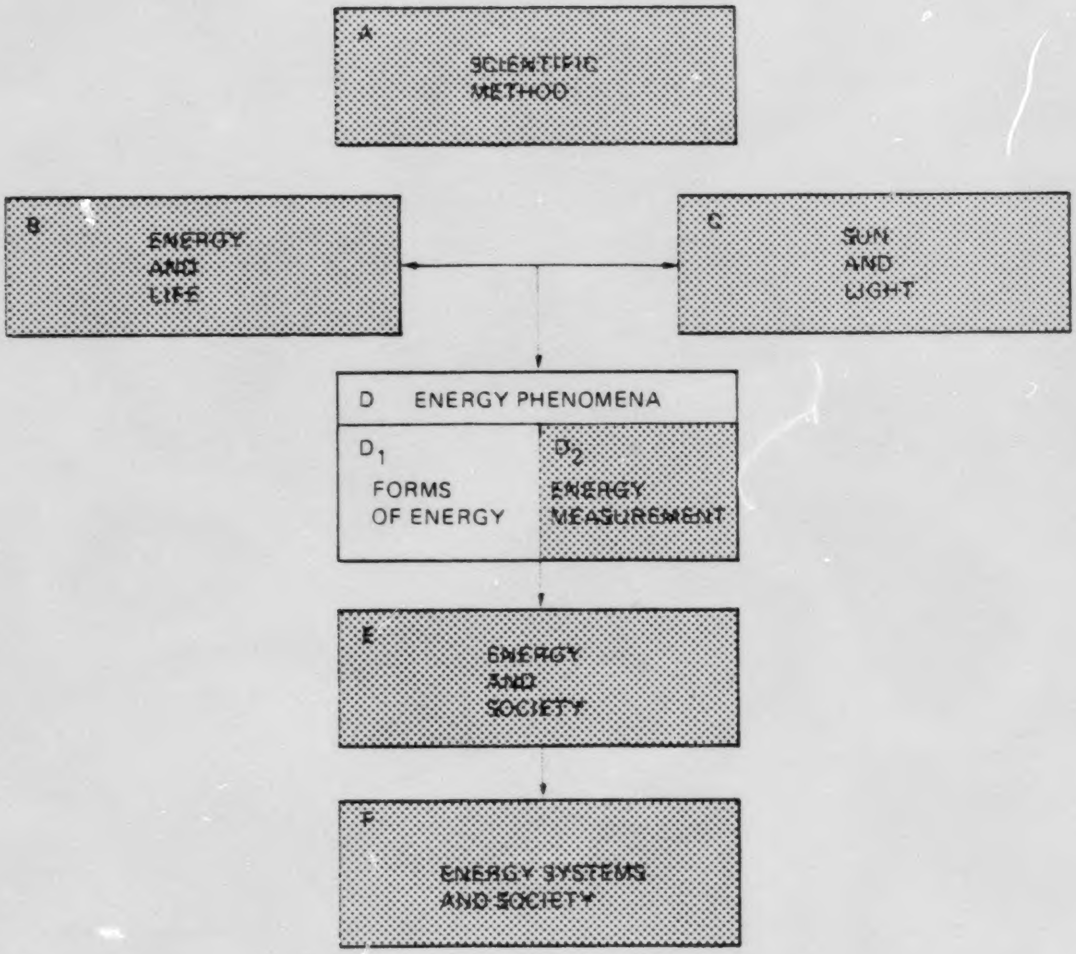
$$\frac{(1.38)^2}{(1.67)^2} = \frac{\text{minimum distance energy}}{\text{maximum distance energy}} = \frac{1.90}{2.79}$$

1.90 goes into 2.79, 1.47 times; so when Mars is closest to the Sun, the solar energy present at the location of Mars is 1.47 times that of when Mars is furthest from the Sun.

5. As can be seen, the Earth has much less variation in the amount of available sunshine during the year than does Mars. This is because the orbit of Mars is not as close to a circle as that for Earth. In fact, the orbit of Mars is famous for being "elliptic". A very famous astronomer names Kepler, was able to calculate certain special astronomical laws using the orbit of Mars just because it was so elliptic.

SPECIAL NOTES

This lesson, not only is fascinating to the students because of the slides of the planet Mars, but allows them to utilize their mathematical abilities to make some interesting deductions and calculations about the planet.


A
SCIENTIFIC
METHOD
B
ENERGY
AND
LIFE
C
SUN
AND
LIGHT
D ENERGY PHENOMENA
D_1
FORMS
OF ENERGY
D_2
ENERGY
MEASUREMENT
E
ENERGY
AND
SOCIETY
F
ENERGY SYSTEMS
AND SOCIETY

D$_1$ FORMS OF ENERGY

Heat is the flow of energy due to a temperature difference between two or more bodies in contact or through a mass medium such as air or water. Heat flows from a higher temperature body to a lower temperature body only (see Figure D-1).

Light is energy that is radiated from the sun or a heat source such as a light bulb. Energy that is radiated does not need a medium to propagate from one point to another such as from the sun to the earth. Space that does not contain matter (such as between the earth's atmosphere and sun), is called a vacuum. Light travels through the vacuum of space and then through the earth's atmosphere to reach us. Examples of radiation are shown in Figure D-2.

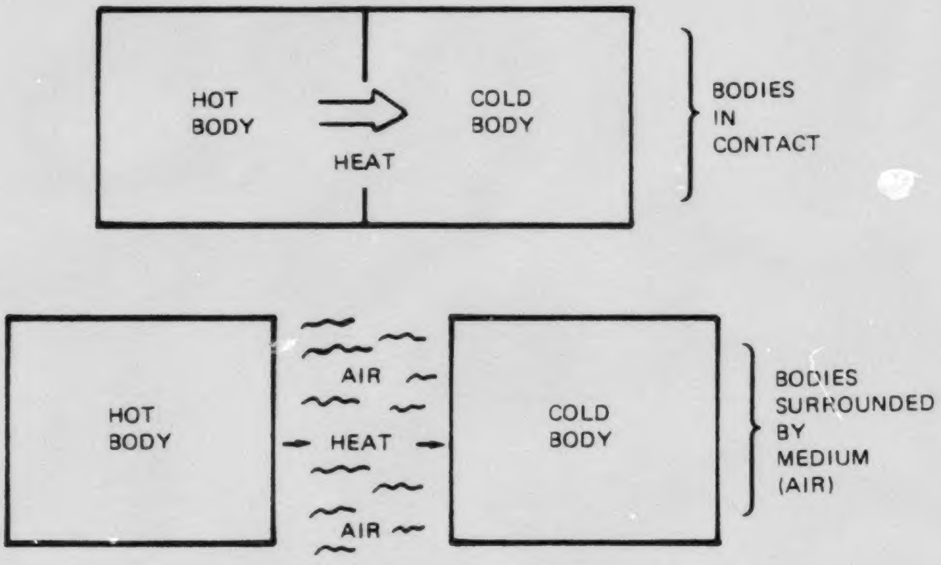

HOT BODY
HEAT
COLD BODY
BODIES IN CONTACT
AIR
HOT BODY
HEAT
COLD BODY
AIR
BODIES SURROUNDED BY MEDIUM (AIR)

Figure D-1. Heat Flow

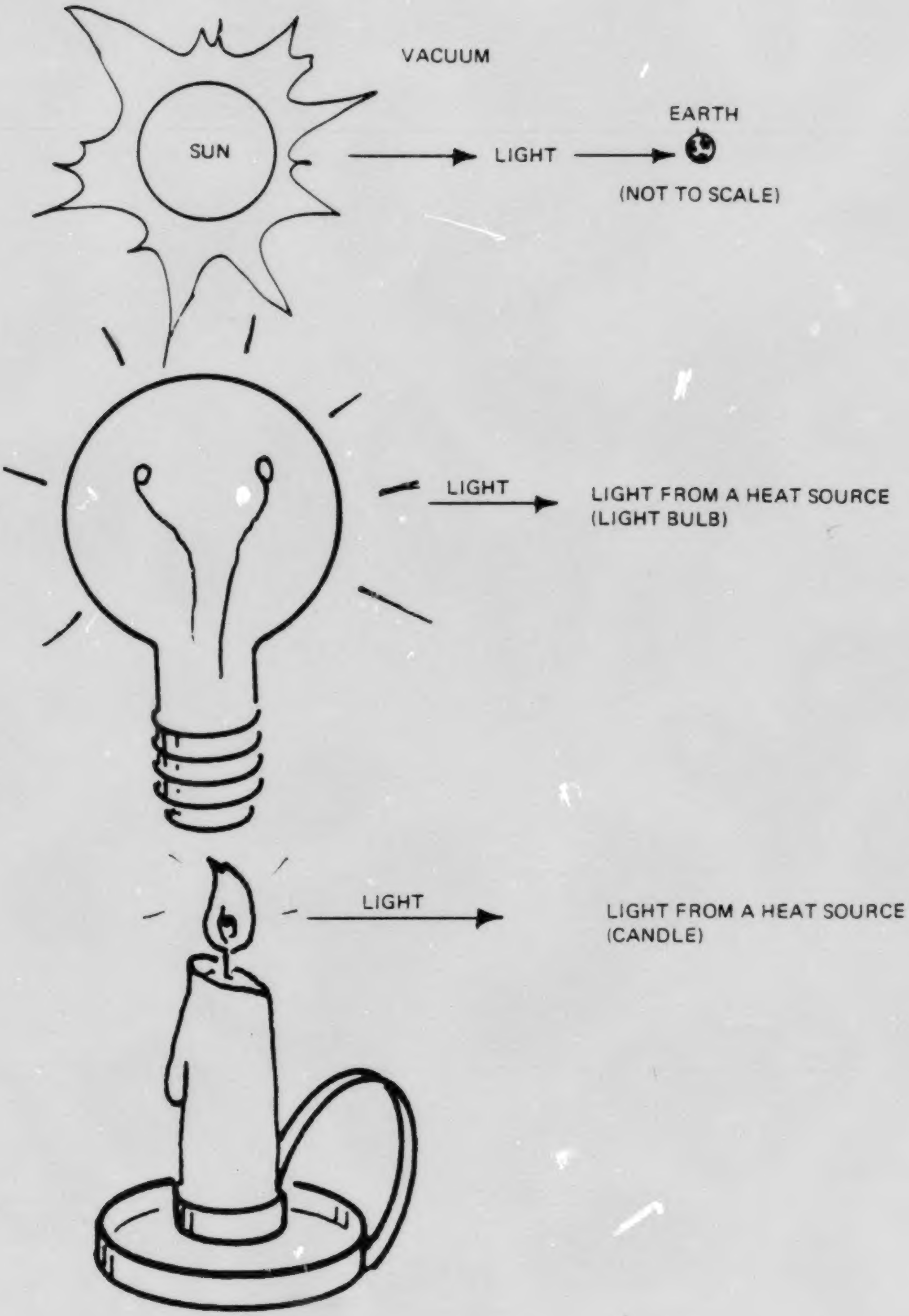

VACUUM
SUN
LIGHT
EARTH
(NOT TO SCALE)
LIGHT
LIGHT FROM A HEAT SOURCE (LIGHT BULB)
LIGHT
LIGHT FROM A HEAT SOURCE (CANDLE)

Figure D-2. Radiation of Light

Chemical energy results in combining chemical compounds in such a way as to release energy. Energy may be stored in chemical compounds. Examples of chemical energy storage is oil and natural gas. Food is chemical energy that has been stored by plants. Animals store chemical energy as fats. Chemical compounds in batteries also represent stored energy.

Nuclear energy involves small particles that combine or divide giving off huge amounts of energy. The dividing process is called fission. Fission occurs in nuclear power plants to generate electricity. Fusion, the combining process of particles requires much higher temperatures than the fission process. Fusion is believed to occur inside the sun where the temperature is millions of degrees Fahrenheit. Unlike chemical energy which changes one form of matter to another to produce energy, nuclear energy comes from changing matter directly into energy. A form of energy that is most commonly used in households and industries is electrical energy. Electricity is a convenient form of energy since it can be easily transported by metal material or conductors made into wires. Two wires are needed to make an electrical mechanism work. (Sometimes a third wire ground is needed to protect anyone from shock). One wire is labeled positive (+) and the other negative (-). To create a positive and negative side of two wires a "voltage" is needed. Voltage is the ability or potential for current to flow. "Current" is the flow of electricity. As water will run from a higher to a lower place, current will run only from a higher voltage to a lower voltage. In this case, current flows from the positive to the negative. More current will flow for higher voltages. The more voltage and current in our wires, the more electrical energy is flowing in our wires and the more energy we can use.

WHAT ENERGY IS AND WHERE IT COMES FROM

D_{1-K} (Approximate Grade Level K)

OVERVIEW

In this lesson, the students achieve an understanding of what energy is, i.e., energy does work, work can makes things move. The last part of the lesson demonstrates to the students that light is solar energy.

LEARNING OBJECTIVES

Students develop a basic understanding that energy is the thing that lets us do work. The students realize energy can have more than one form and that the sun gives us our energy.

EVALUATION

The students should demonstrate an awareness of the basic physical properties of the sun (heat and light) through participation in the playground experiments and during the coloring exercise.

SPECIAL MATERIALS

- A few pieces of black construction paper
- Pre-assemble "10c hot dog cooker" (detail construction plan included with lesson plan and in applications section)

VOCABULARY

Energy, work, light, heat, sun, solar

LESSON PLAN

(This lesson is best accomplished as the first lesson of the day.)

- Ask the students if they all had a good breakfast and feel like working in class today. Draw an analogy between eating the breakfast which gives them energy and their ability to do things in class which are work.
- Ask the students to stand up, push their chairs in behind their desks, stand there for a moment, then pull their chairs back out and sit down.
- Tell them they just used "energy".
- Take the students outside to look for energy.
- Take the black piece of construction paper and lay it in a sunny spot. After a few minutes, have the students touch the paper. It will feel warm, this is energy. Light energy has struck the black paper and the black paper turned it to heat energy.
- As final demonstration of light and heat energy, put a hot dog in the hot dog cooker and aim it to the sun. Show the students how the light energy comes in and strikes the aluminum foil and is reflected back onto the hot dog. Tell the students that the hot dog will take the light energy and make it into heat energy and that way the hot dog will be cooked.

- Leave the hot dog in the sun for an hour or more.

- Return to the classroom with the students and have them draw pictures of things in sunlight being warmed by the sun or things that are moving and doing work.

- After about an hour or more, bring in the hot dog cooker with the hot dog.

- The students can feel the warmth of the hot dog and then the hot dog can be cut into small pieces so that each student can taste a bit of the meat.

- As the students are eating, again point out to them how the light energy of the sun was made into heat energy to heat the hot dog and that they are using energy when they eat it.

SPECIAL NOTES

It should be noted that the hot dog cooker works best on a bright clear day. In addition to demonstrating the inter-relationships of light and heat, the hot dog cooker can also illustrate to the students how we can use solar energy to do tasks that we normally use fossil fuels for now, i.e., such as cooking.

D_{1-I}

WHAT IS ENERGY AND WHERE DOES IT COME FROM

Unit D_{1-I} (Approximate Grade Level #1)

OVERVIEW

Using picture identification, a black painted bottle and the "10c Solar Hot Dog Cooker", students increase their understanding of the various forms energy can take. In particular, this lesson highlights mechanical, thermal, and light energy forms. The students can also see these energy types in the normal things around them such as the black top play area and small mechanical toys they may have.

LEARNING OBJECTIVES

Students will grow in their ability to recognize various forms of energy, and their association with the sun.

EVALUATION

Students will demonstrate knowledge of the concept of energy through participation in demonstrations of energy at work and by identifying pictures of various forms of energy.

SPECIAL MATERIALS

- Set of pictures of different types of energy being used.
- Empty pop bottle with some black paint.
- Solar 10c hot dog cooker.

VOCABULARY

Heat, thermal, light, radiant, mechanical, energy, work, sun, solar.

LESSON PLAN

Show the students various pictures of energy being used (see special notes for suggested pictures) and note the accuracy of the students in identifying whether the type of energy used is heat or thermal energy, light or radiant energy or mechanical energy.

- Show the students a picture illustrating a type of energy, have the students indicate by a show of hands whether it is mechanical, heat or light energy and record this information for the pre-lesson motivation.

- Tell them the energy they used when things are moved is called mechanical energy (an optional demonstration at this point is the use of a chalk-ruler-eraser catapult). Take the eraser, put it on the table top and lay a twelve inch ruler across it as a teeter-totter with one side down on the table and the other side angled up over the eraser. Put a small piece of chalk on the end that is lying on the table and with your hand, smartly hit the other end of the eraser. The chalk goes flying across the room and the students are usually very excited about this demonstration of mechanical energy.

- After the students have indicated their thoughts, discuss with them the types of energy shown in the pictures.

- Introduce to the students the words thermal, associated with heat energy; the word radiant, associated with light energy and, or course, mechanical energy.

- Tell the students that they will now use some mechanical energy to make a device that will take the sun's light energy and convert it to heat energy.

- Have the students paint a bottle black with black poster paint.

- As soon as the paint is dry, fill the bottle with water and take it outside.

- Put the bottle in the sunlight and at the same time, if you wish, put a hot dog into the 10c solar hot dog cooker as used in Unit K. Aim that at the sun also.

- Return the class to their desks and have them draw pictures of machines that use mechanical energy, heat energy, or light energy.

- Just before the lunch period, (note the bottle and hot dog should stand in the sun for at least an hour) take the class back outside, have the students feel how warm the bottle is and have them examine the hot dog to see if it is cooked.

- Bring the bottle, the hot dog cooker back into the room; pour the warm water into another container where the students can feel it.

SPECIAL NOTES

When you are outside, if your play area has been blacked topped and it is a warm day, the heat energy rising cause air movement such that when students kneel down and look close to the pavement, the things they see will appear wavy. This is also a good illustration of heat energy. Students may also be asked to bring in small toys, flashlights or other items they may have at home that illustrate the use of different kinds of energy. These can be combined with a "Show and Tell" session or other class extension of discussion of energy. Also see for example Figure D-3.

A TEN CENT SOLAR HOT DOG COOKER

BASIC MATERIALS YOU WILL NEED

1. Two pieces of heavy cardboard (like the side of a cardboard carton). The first piece must be at least ten inches square and the second smaller piece must be at least four inches by five inches.

2. A piece of light posterboard eight inches wide and sixteen inches long.

3. Twelve inch wide aluminum foil (you will use about 32 inches of the material).

4. Some masking tape.

5. Nine inch long sticks about 1/16 inch in diameter. You may also use lengths of heavy wire. (You may find at your local grocery store in the international food section small bamboo sticks imported from Japan to make shish kebobs. These are very inexpensive and will do the job very well.)

6. Four one inch long spreading brass brads.

NOW LET'S MAKE IT

____ 1. Using a large compass or a string and pencil, lay out a ten inch diameter circle on the larger piece of heavy cardboard. Cut out this circle using a large scissors or a sharp knife.

____ 2. Draw a straight line (line "1") through the center pinhole in the cardboard, (i.e., a line along the diameter of the circle).

____ 3. Mark off points at 2-1/2 inches (hole "a") and 3-1/4 inches (holes "b") on either side of the centerpoint along the straight line you just have drawn.

____ 4. Draw a straight line (line #2) 3/4 inch on one side of the straight line through the center.

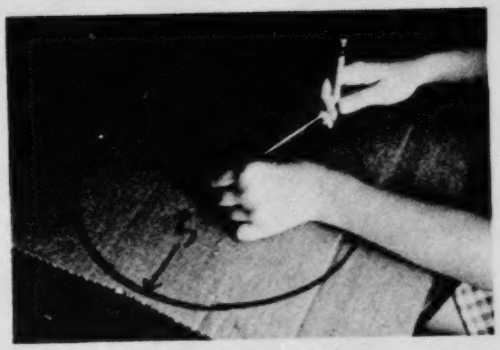
____ 5. Draw a line that goes at right angles to the lines you have drawn and through the center hole (line #3).

____ 6. Mark off holes that are 4-1/4 inch (holes "c") on line #2 from line #3.

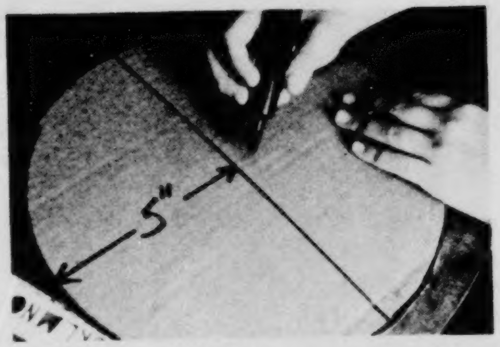
____ 7. Using an ice pick or other sharp instrument, punch out the holes "a," "b," and "c".

____ 8. Using a sharp knife or razor blade, cut along line #3 so that the cardboard circle is cut in half.

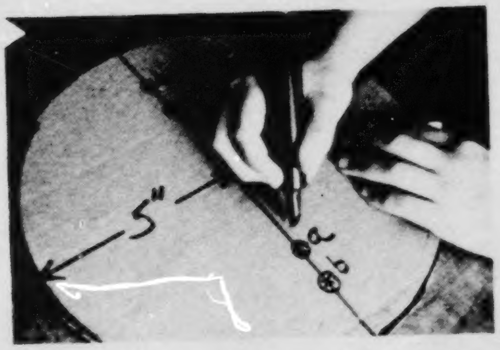
____ 9. Put the cardboard semicircles to one side now and get your piece of posterboard. (It should already be eight inches wide and sixteen inches long.)



STEP 1



STEP 2



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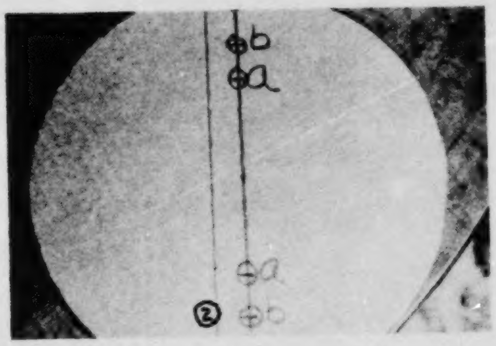

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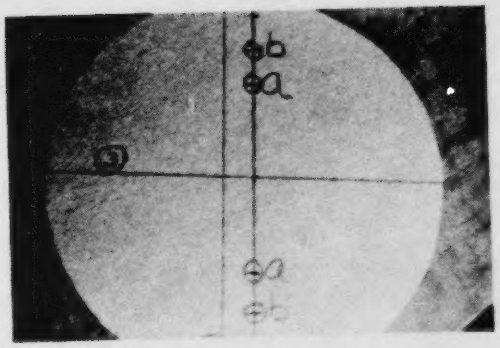
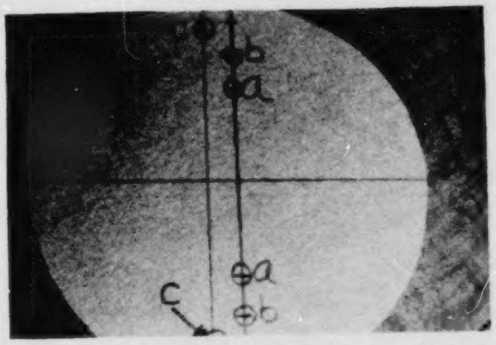


STEP 5



STEP 6

____ 10. Take a piece of aluminum foil that is about 18 inches long (and, of course, twelve inches wide).

____ 11. Lay the shiny side of the foil down on the table and put the piece of posterboard on top of it — center the board so that there is roughly an equal amount of foil sticking out on all sides.

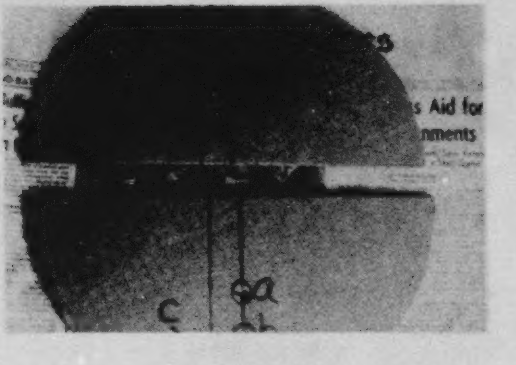
____ 12. Fold the aluminum foil over the posterboard so that the side of the board facing down on the table will be foil covered. Put a few pieces of masking tape at the corners and along the sides to hold the foil securely in place. Put the foil-covered posterboard to one side for a moment.

____ 13. Take the two half circles of heavy cardboard. These will be the sides of the hot dog cooker. Hold them up for a moment so that you can see how the holes line up.

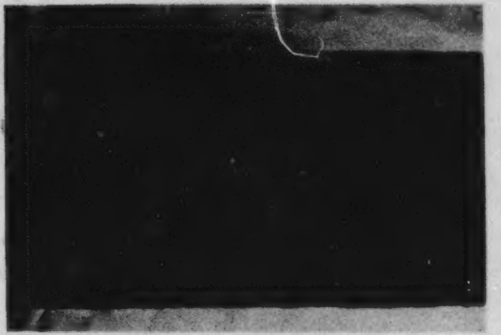
____ 14. Mark the sides of the half circles that are on the outsides away from where the hot dog will be, with an "0" (for the "outside," of course!).

____ 15. Mark the other sides with an "I" (you guessed it — for "inside"!).

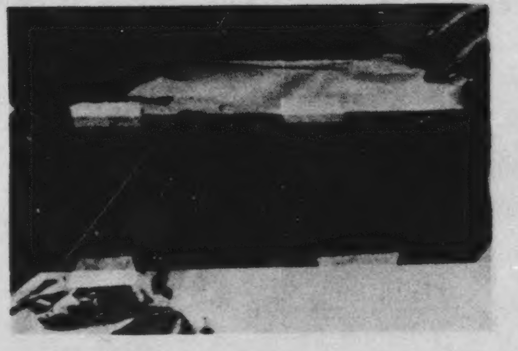
____ 16. Get two more pieces of aluminum foils that are about seven inches long (of course, again, twelve inches wide). Lay one of the pieces down on the table, shiny side down, as you did with the larger piece of foil.


s Aid for
nments
c
a
b

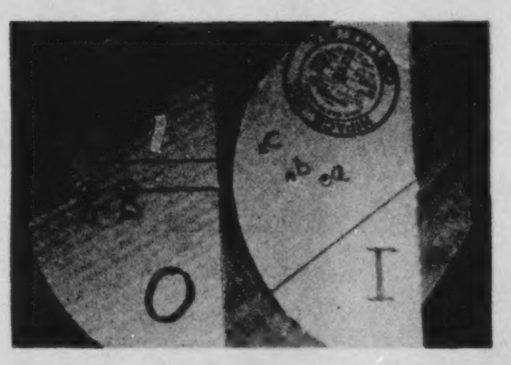
STEPS 7,8



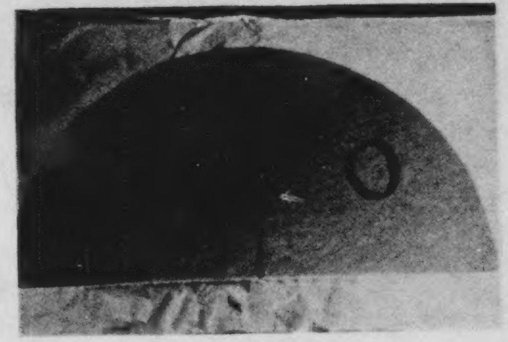
STEPS 9,10,11



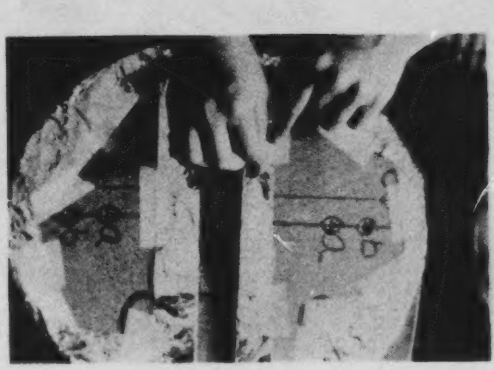
STEP 12



STEPS 13,14,15



STEPS 16,17



STEPS 18,19,20

____ 17. Put one of the half circles with the "I" (inside) side down onto the foil (the "0" side will be up). Again, center the piece of cardboard on the foil.

____ 18. Fold the foil over the cardboard and tape the foil to hold it.

____ 19. Make sure you find the "a," "b," and "c" holes and poke them through the foil.

____ 20. Do the same thing with the other half circle of cardboard so that it is also foil covered on the inside surface.

Now, we will assemble the back and sides of the cooker.

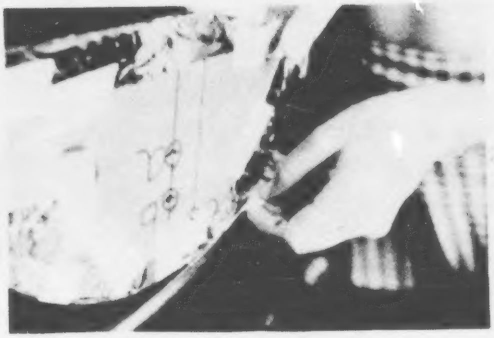
____ 21. Lay the aluminum-covered posterboard down on the table with the aluminum-covered side up.

____ 22. Take one of the aluminum-covered half circles. Hold it so that the aluminum-covered side faces in towards the aluminum cover on the posterboard, and also so that the outside edge of the half circle (where it was cut along line 3) lines up with the edge of the posterboard.

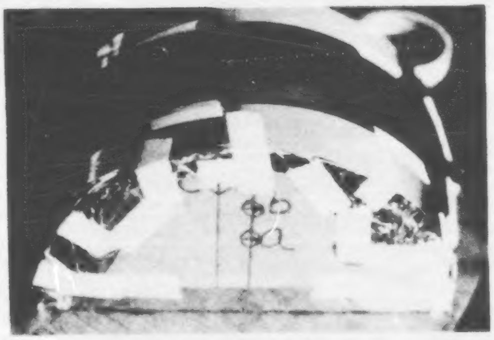
____ 23. Put a piece of tape from the posterboard to the cardboard so that the cardboard half circle stands up on the aluminum-covered posterboard.

____ 24. Now roll the aluminum-covered half circle along the edge of the aluminum-covered posterboard, putting a piece of tape every two or so inches as you go. Make sure there is a snug fit between the aluminum half circle side and the foil-covered back posterboard.

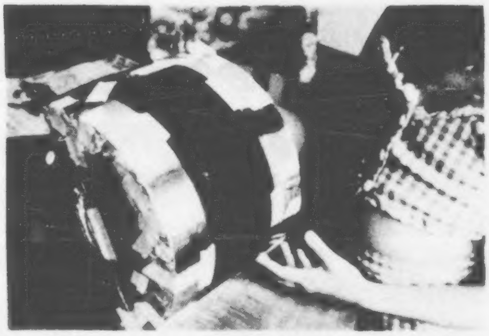
STEPS 21,22,23



STEP 24

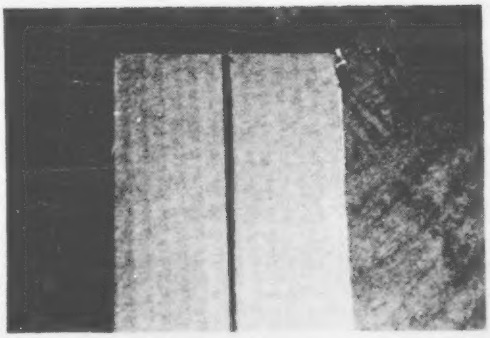


STEP 25



STEP 26

STEPS 26,27



STEP 28

____ 25. Continue until the half circle (with the aluminum foil on the inside) is attached to the aluminum foil-covered posterboard. (This will make one end of a trough.)

____ 26. Now attach the other foil-covered cardboard half circle, with the aluminum-covered side facing in, to complete the trough. Use a similar technique as you did with the other piece of cardboard using tape every two or so inches.

____ 27. Put the trough to one side.

We are almost done now!

____ 28. Take the small piece of heavy cardboard (four inches by five inches) and draw a line (line 4) down the center along the five-inch length.

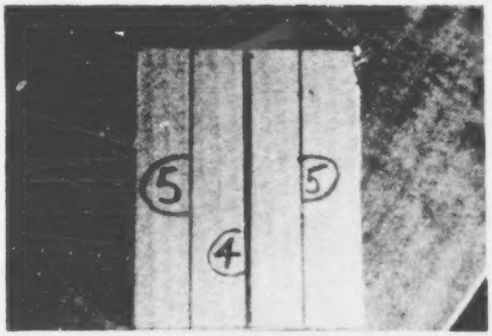
____ 29. Draw a straight line one inch on each side of line 4 (lines #5).

____ 30. Mark off points one-half inch and 1-5/8 inches along line 5 from one end of the cardboard (holes "d").

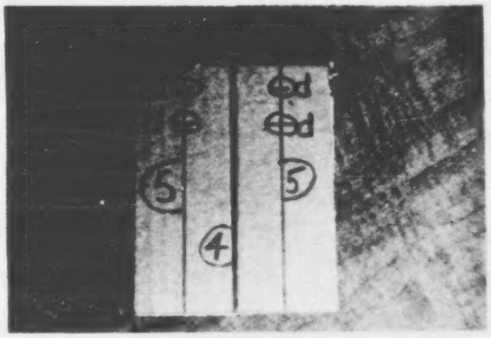
____ 31. Punch out holes "d" using an ice pick or sharp instrument.

____ 32. Using a sharp knife or razor blade, cut along line 4 so that you have two pieces of cardboard, each two by five inches.

____ 33. Put two brass brads from the inside of the trough through holes "b" and "c", and through holes "d" on the two-inch by five-inch piece of cardboard. Spread the brad so that the rectangular piece of cardboard is securely attached to one side of the cooker.

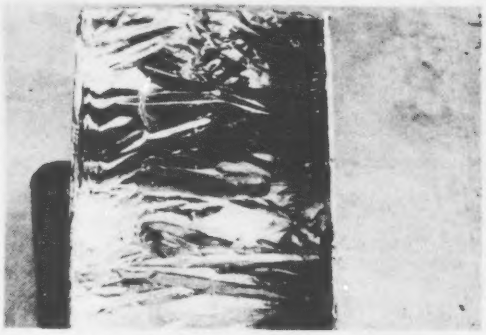


STEP 29

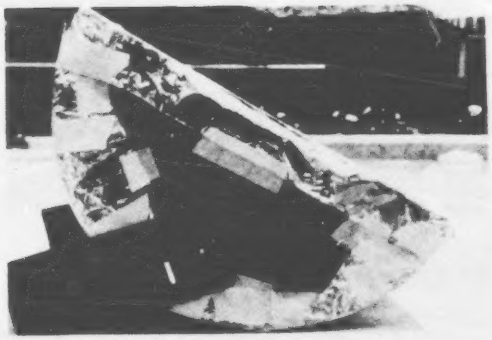


STEP 30

STEPS 31,32,33,34



STEPS 35,36,37



STEP 38

STEP 39

____ 34. Do the same thing on the other side of the cooker with the remaining piece of two-inch by five-inch cardboard.

These pieces of cardboard act as legs to prevent the hot dog cooker from just rolling around on the table.

NOW, YOU ARE READY TO START COOKING!

____ 35. Slide the stick from the outside in through one of the "a" holes.

____ 36. Hold the hot dog so that as you slide the stick further in through the "a" hole, you also put the stick through the length of the hot dog.

____ 37. Continue until the stick is completely through the hot dog. Then, put the stick about one-fourth inch through the other "a" hole so that the stick and hot dog are supported at both ends. Center the hot dog on the stick.

____ 38. In summer, stand the cooker so that the opening looks more upward and, if winter, turn the cooker over so that the opening faces more downward.

____ 39. Aim the hot dog cooker toward the sun. It will take about 45 minutes to one hour, and then ... HAPPY HOT DOG EATING! Note: You can shorten your cooking time by stretching a piece of clinging plastic wrap over the whole front of the cooker after the hot dog is on the stick. This will keep the hot dog from cooling down as the wind blows over it. If you or your class come up with any special recipes using the cooker, please send a copy to the author so that he can let others know about it, giving proper credit. Thank you. Enjoy solar cooking.

ENERGY, WHAT WE USE IT FOR AND WHERE IT COMES FROM

Unit D_{1-II} (Approximate Grade Level #2)

OVERVIEW

The students are introduced to five forms of energy; heat, light, mechanical, electrical, and chemical energy. Students are also shown that to do more work, requires a greater expenditure of energy.

LEARNING OBJECTIVES

Students grow in their knowledge of the forms that energy can take and develop a fundamental concept of the fact that it takes more energy to do more work. These concepts are again correlated with the sun's energy.

EVALUATION

Students should demonstrate a two-thirds accuracy knowledge of the various types of energy illustrated in the special worksheet after the class discussion has been completed. The students should also recognize that to do more work, requires the use of additional energy.

SPECIAL MATERIALS

- Special energy worksheet
- "Sun-of-a-cell" (optional) or small flashlight
- Small pie pan or shallow metal container that has a large surface area
- 10¢ solar hot dog cooker (optional)

VOCABULARY

Energy, work, thermal, heat, radiant, light, mechanical, chemical, electrical, evaporation.

LESSON PLAN

Motivation is accomplished by recording the students accuracy in working with the special energy work sheet provided.

- Pass out the special energy work sheet (Figure D-3).
- As a pre-lesson motivation, have the students write in the space under each picture all of the various forms of energy they can visualize. This can be done by using the words, heat, light, mechanical, chemical or electrical. It should be noted that more than one form of energy may be presented; i.e., with the flashlight, the batteries represent chemical energy, which in turn, produces electrical energy, which in turn makes the light bulb grow bright with light energy. It also heats the lightbulb and we need mechanical energy to turn the switch on.
- Take the sun-of-a-cell solar demonstrator (additional copy in Application Section) and place the solar cell in the beam of a projector light bulb or go outside with the students and aim the cell at the sun. Refer to the material supplied in this lesson. Discussing the use of the sun-of-the-cell demonstrator to illustrate various types of energy. At this level, the students need not be introduced to the concept of acoustical energy.
- Turn the sun-of-the-cell away from the light so that the propellor slows down. Ask the students if they think the sun-of-the-cell is doing less work. (The sun-of-the-cell is moving less air and therefore doing a lessor amount of work.)

As the students if they think, threfore, the machine is using less solar or light energy.

- Use a small flashlight and turn it on. Show the students that the batteries are taking chemical energy converting that into electrical energy to make the light bulb go bright.
- Hold the light on for a short period of time and then a longer period of time. Ask the students if they thought more chemical energy was used when the light bulb was held on for longer period of time.
- Move an item across your desk for a distance of about one foot. Ask the students what type of energy was used to do task. The answer is mechanical energy. Move the item two feet across your desk and ask the students if you used more mechanical energy the second time.
- Pose the question to the students what energy is used to make rain.
- A demonstration to illustrate this is to take the pie pan that has been painted black on the inside, fill it with a layer of water and go outside.
- Put it in the sunlight and at the same time reillustrate the sun-of-the-cell demonstrator (the solar hot dog cooker can also be set up at this time if you wish.)

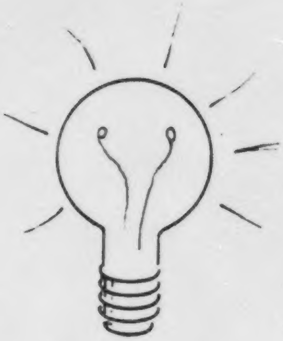
- Take the class back into the room and have them draw a series of pictures illustrating the use of energy, the use of more energy and the use of still more energy. Later in the day, go outside and see if the water has evaporated. Explain to the students that the solar light energy heats the water which in turn evaporates. This water then goes into clouds and when clouds are formed, and when weather conditions are right, the water may cool and condense and produce rain.

- You can pose the question to the students which use more energy, a light or a heavy rainstorm.

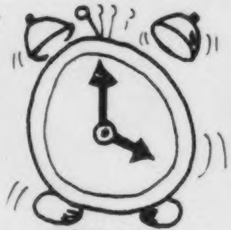
SPECIAL NOTES

Quite a bit of new material is included in this lesson and teachers may desire to make a two lesson format rather than a single lesson. The evaporation experiment could be done later or as stand alone endeavor. The sun-of-a-cell demonstrator adds excitement to the lesson, but essentially the same material may be delivered using only a small flashlight. Some of the material sin the information regarding the sun-of-a-cell solar demonstrator can be used as a supplementary or additional material for extension of this lesson and some of the other lessons.

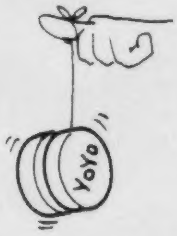
KINDS OF ENERGY – WORKSHEET



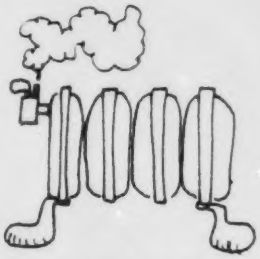
MECHANICAL
LIGHT______
HEAT______



MECHANICAL
LIGHT______
HEAT______



MECHANICAL
LIGHT______
HEAT______



MECHANICAL
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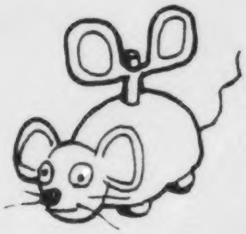

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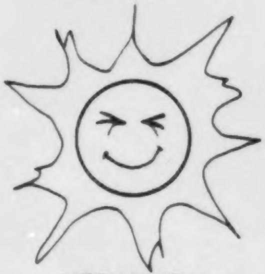

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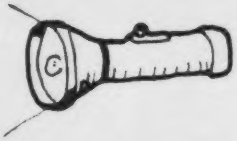

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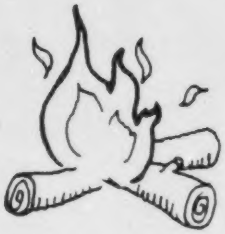

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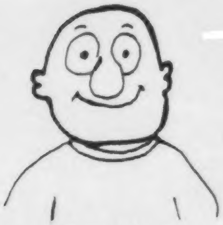

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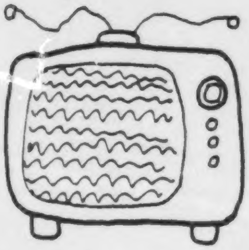

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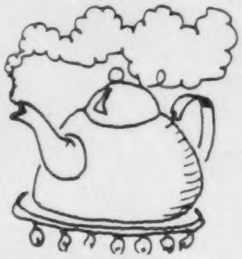

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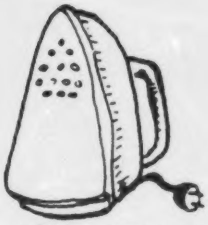

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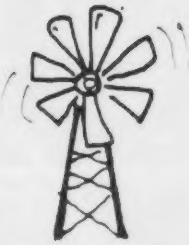

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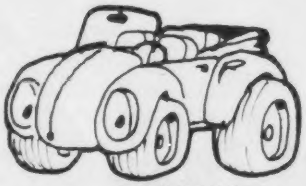

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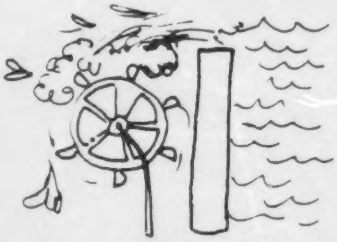

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Figure D-3. Kinds of Energy Sample Work Sheet

SUN-OF-A-CELL

SOLAR DEMONSTRATOR

WHAT IS A "SUN-OF-A-CELL"?

The "Sun-of-a-Cell" solar energy demonstrator is not only a unique teaching aid, but it is also a "semi-practical" device in that it may be used as a personal cooling fan on bright sunny days.

WHAT MAKES IT GO?

The basic driving force is supplied by a "silicon photovoltaic" cell, the round dark blue and silver two inch diameter disk on the plexiglass stand. Silicon cells are amazing devices. The basic material silicon, of which they are constructed, is the second most abundant element on Earth and it is, of course, what sand is made of.

By itself silicon does nothing — otherwise we might all be given electric shocks at the beach everytime the Sun comes out! However, when small traces of other elements (usually boron and phosphorus) are put in with specially prepared silicon we have the start of a silicon cell. Other processes are required like the ones that put the silver colored lines on the surface which act as wires to allow us to get the electricity from the cell.

The finished silicon photo cell, like a battery, produces both voltage and current. Each silicon cell, regardless of its size, will produce about one-half of a volt (a normal flashlight battery will produce about one-and-one-half volts). The current a cell can give is a function of how big it is, just as we can get more current out of larger batteries than smaller batteries. The cell in the "Sun-of-a-Cell" is rated at about one-half volt at one-half amp.

THE "SUN-OF-A-CELL" AS AN ENERGY DEMONSTRATOR

Energy is the ability to do work. The more energy we have, like after a good healthy breakfast, the bigger the job that can be done. Energy may take different forms. Looking at the "Sun-of-a-Cell" happily spinning in the sunlight we can point to at least six types of energy. Take a moment to list the kinds of energy that you think are shown before reading on ...

Now let us look at the "Sun-of-a-Cell" together. There is the light energy shining on the cell (1); there is the electric energy that the silicon cell produces (2); not all of the light or radiant energy goes into electricity, much of it just goes to make the cell warmer, heat energy (3); the electric energy makes the motor turn, mechanical energy (4); the spinning propeller causes the air to gently blow toward us (i.e. our personal cooling fan) — bring your hand close to the propeller without touching it or shading the cell and feel the wind energy (5). Now what is the last one. Listen to the morot turn, acoustical or sound energy (6).

THE "SUN-OF-A-CELL" AS A SCIENTIFIC INSTRUMENT

At the beginning it was mentioned that the "Sun-of-a-Cell" was a semi-practical device as it could be used as a low velocity personal cooling fan. The propeller spins fastest in direct strong sunlight. You can use this rate of spin as an indication, therefore, of how much sunlight is falling on the cell and can use this reaction for a series of simple solar experiments. A couple of these are listed below.*

---

*It is anticipated that many teachers and individuals may discover other practical and scientific uses for the "Sun-of-a-Cell." The author would be most grateful to hear of these so that he may incorporate them into future literature, with proper credit always being given.

Solar Intensity — Aim the cell at the direct sunlight and note the rate of spin. Compare this spin rate to when a cloud passes in front of the sun or when the "Sun-of-a-Cell" is put in the shade. As a corollary, see just how much sunlight is needed to start the motor from scratch. Note there will be more energy needed to overcome starting friction. Try starting the propeller in the shade or on a dull day with a push from your finger and see if it will keep going, if it will not start by itself.

One Must Aim Solar Collectors South (Northern Hemisphere) — Turn the "Sun-of-a-Cell" toward the north and see how fast it spins. Does it spin at all? In the northern hemisphere the Sun is always to our south. This little experiment will show that to get the most energy collected we must make sure our solar devices are aimed to the south.

WHAT ENERGY IS, HOW IT IS USED, AND WHERE DOES IT COME FROM

Unit D_{1-III} (Approximate Grade Level #3)

OVERVIEW

The students are shown again five forms of energy, namely thermal or heat energy, radiant or light energy, mechanical, electrical energy and chemical energy. In this lesson, the students are shown that the fossil fuel energy we now have on earth is actually stored solar energy. The students are also introduced to the concept of picking an appropriate energy to do a certain task as illustrated in a special set of sort cards.

LEARNING OBJECTIVES

Students continue to grow in their understanding of the interchangeability of various types of energy and the connection bewteen using energy and doing work.

EVALUATION

The students should achieve at least 70% accuracy when redoing a special energy worksheet after presentation of the lesson.

SPECIAL MATERIALS

- Special filmstrip illustrating fossil fuel cycle (applications section)
- Sun-of-a-Cell solar demonstrator (optional)
- Special student energy worksheet, Figure D-3
- Special set student sort cards
- Material required to make a solar 10¢ hot dog cooker (see enclosed information).

VOCABULARY

Energy, work, heat, thermal, radiant, light, mechanical, electrical, chemical, fossile fuel.

LESSON PLAN

Using a specially supplied worksheet, the students are asked to identify various forms of energy shown and which pictures require more energy than others.

- Carry out the motivation using a special worksheet. After the students make their decision on the types of energy shown, go over the worksheets and have discussions in relation to each of the pictures and the types of energies that the students think are shown. Also discuss with them which pictures are requiring more energy than others.
- Pose the question to the students of what makes automobiles go. Lead the discussion to the topic of fossil fuels.
- Show the special film strip discussing fossil fuels and where they come from.
- Have a discussion with the students in relation to how we may use different types of fuels to produce different types of energy. For example, the use of heat energy for cooking. See how many different kinds of fuels the students can think of to produce heat for cooking, e.g., electricity, natural gas, kerosene, wood. Each time the students bring up a fuel

source, see if they can trace back its origin. They should trace the production of a fuel source back to the sun.

- Ask the students if there is a way of using the sun's energy directly for cooking.
- As a class project, have students make their own solar 10¢ hot dog cookers (if this part of the activity plan is done, it is suggested as a homework problem, the student find cardboard and the necessary material that they will need).
- When the students have prepared their hot dog cookers, they may take and use them or take them home. If the class steps outside, use the-sun-of-a-cell solar demonstrator and have the students identify all of the forms of energy illustrated.
- Conclude the lesson by having the students again use a special worksheet.

SPECIAL NOTES

If the solar hot dog cookers are made, it is recommended that it be done as a morning project. The units may be taken home or they may be saved until the following day. In the latter case, have the students put their hot dogs in about an hour or two before the lunch period, and the hot dogs should then be delicately cooked by the noon meal time. Another additional exercise would be for the students to go home and make lists or mental notes of items in their homes that use energy and the types of energy they use. This information could be used the following day during a sharing period. The inclusion of the-sun-of-a-cell solar demonstrator is optional, but its use has proved to add excitement to the lesson.

How to play and build the mouse trap game®

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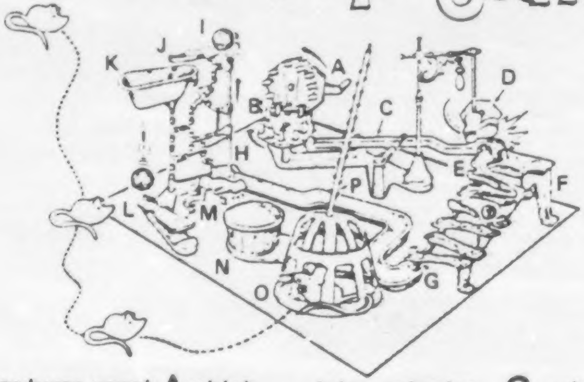
HOLLIS, NEW YORK 11423
2L-0811



1. CIRCLE ALL THE LETTERS WHERE THERE IS POTENTIAL ENERGY
2. WRITE IN A T AT EVERY POINT WHERE ENERGY IS TRANSFERRED
3. WRITE IN N.E. EVERY TIME NEW KINETIC ENERGY IS ADDED

Player turns crank A which rotates gears B causing lever C to move and push stop sign against shoe D. Shoe tips bucket holding metal ball E. Ball rolls down rickety stairs F and into rainpipe G which leads it to hit helping hand rod H. This causes bowling ball I to fall from top of helping hand rod through thing-a-ma-jig J and bathtub K to land on diving board L. Weight of bowling ball catapults diver M through the air and right into wash tub N causing cage O to fall from top of post P and trap unsuspecting mouse.

A ______________________

B ______________________

C ______________________

D ______________________

E ______________________

F ______________________

G ______________________

H ______________________

I ______________________

J ______________________

K ______________________

L ______________________

M ______________________

N ______________________

O ______________________

P ______________________

Figure D-4. How to Play and Build Mouse Trap Game

RENEWABLE/NONRENEWABLE CONCEPTS

Unit D_{1-IV} (Approximate Grade Level #4)

OVERVIEW

Using a simple word game, the class as a whole will engage in an indepth discussion of the concepts of renewable and nonrenewable. This discussion will center on the subject of renewable and nonrenewable energy sources, but experience has shown that the students may carry these ideas to subject areas other than simply energy sources.

LEARNING OBJECTIVES

Students will obtain an indepth understanding of the meaning of renewable and nonrenewable energy sources and concepts.

EVALUATION

Students will obtain a basic understanding of the concepts of renewable and nonrenewable. Students will achieve an indepth understanding of the concepts.

SPECIAL MATERIALS

No special materials are required for this lesson.

VOCABULARY

Renewable, Nonrenewable, Fuels, Energy Sources

LESSON PLAN

The teacher can review the material in lesson E_{II} to refresh the students' concepts of renewable and nonrenewable energy sources. The teacher can also carry out classroom demonstrations such as using the magnifying glass to set paper afire in comparison to using a match to do the same task. The magnifying glass can be used over and over again, i.e., the solar energy is renewable and can be used many times. However, the match can only be struck and lit once. The fossil fuels that it uses are consumed and then the match is useless. This is a nonrenewable energy source. The teacher can carry on a discussion with the class of such items as coal, oil, wind energy systems, natural gas, title energy systems, and etc., having the students in each case discuss whether these energy sources are renewable or nonrenewable. The teacher can then pose the question to the students, "Which group understands the concepts of renewable and nonrenewable best? Boys or Girls?" The teacher can then suggest that a game be played to determine the actual winners.

ACTIVITIES

- The class can be divided into boys and girls. The basic concept of the game is very simple. One team member will say an item, such as coal. The other team member must say whether it is renewable or nonrenewable. The class as a whole, will carry out a discussion to determine whether the answer is correct. The subjects can get very deep very quickly. For example, a concept of a forest. A forest, as a whole, is renewable. You can harvest the trees at one end of the forest while you are replanting at the other. However, any single tree is nonrenewable. Once it is cut down, that is the end of it.

- The game continues, first with one side, say the boys suggesting an item and then the other side, the girls answering it. The next round the girls will suggest the item and the boys will answer it. After each item, the entire class will engage in a discussion to make sure every one agrees upon the answer. Each time a team successfully answers the question, that team scores a point. The team that scores the most points, obviously wins.

- Experience has shown that before the teams have all had a turn, all of the concepts of energy sources will be covered. Consequently, the students will think about this concept of renewable and nonrenewable in relation to other subject areas. For example, students have suggested the subject of people! This is the opposite situation from the forest.

- Many classes have spent surprisingly long periods of time in this game. The actual time spent will depend a great deal on the level of the students, their interest, and depth of competitive spirit.

SPECIAL NOTES

The teacher plays a most important part in the game. The teacher acts as a moderator and, in essence, the director of the discussions. The curriculum development team will be most appreciative of any feedback from teachers using this lesson, especially as they relate to unusual or interesting concepts.

ENERGY AND LIFE

D_{1-V} (Approximate Grade Level #5)

OVERVIEW

Using a modified standard Monopoly game with short game rules, the class engages in a Monopoly game. The modified game will not only illustrate the standard economics techniques of adult life that exist with the Monopoly game, but will illustrate to the students, problems connected with lack of available energies, use of insulation, use of solar energy, interaction with local laws, and in general, give the students an insight into the interactions of technology, politics, economics, environmental issues, laws, and the desire of everyone to have a good standard of living.

LEARNING OBJECTIVES

Students will be able to recognize how political, economic, environmental, sociological, and institutional issues after the use of energy and solar energy applications.

SPECIAL MATERIALS

- A standard monopoly game
- Special energy rules
- Special energy cards and chips.

VOCABULARY

Energy, tax rebate, conversion, collectors, brownout, blackout, insulation.

LESSON PLAN

The students will first have to make certain additional items that will be used in the game.

Have the class make 250 "energy chips." The class can discuss what they think an energy chip should look like, and after a suitable design is decided upon, a class composed of many teams can make the chips.

The class must also make additional energy cards. This again, can be done as a classroom project. Twenty-two additional cards will be made.

Monopoly Cards

These should be printed on tag in the following size to be cut up by teacher.

Chance & Community Chest Cards

1. Tax rebate! You receive $100.00 for each solar home, $150.00 for each solar hotel.

2. Backup system failed! You pay $100.00.

3. Government selected one of your nonsolar homes for conversion to solar. You choose the property.

4. High Rise Apartment Complex built next door — your solar collector is shaded. Pay $100.00 legal fees.

5. Blackout! If you have solar energy/house, receive 10 energy chips, if not pay 10 chips.

6. Brownout! If you have solar energy/house, receive 5 chips, if not pay 5 chips.

7. Price of Fossil fuels has skyrocketed — pay $50.00 for each house, $50.00 for each hotel.

8. Rising utility costs force you to convert one house to solar — pay up!

9. Extreme weather conditions — did not install backup system! Pay $200.00.

10. Solar design safe from sabotage and vandalism. You get $50.00.

11. You design new solar collector. Collect $20.00 from each player.

12. Installed larger storage tanks! You receive 15 energy chips.

13. Neighbor sues for unsightly collector. You win case! Collect $100.00.

14. Energy Rebate! You receive 20 chips!

15. You left all the lights on in your house. Pay 4 energy chips.

16. You put low watt light bulbs in your home. Receive 4 energy chips.

17. Make repairs on your solar system.
    Pay $25.00 each solar home
    $100.00 each solar hotel.

18. Advance token to nearest railroad. Due to rising cost of fossil fuel, pay $20.00 more than rental price.

19. Due to rising cost of fossil fuel, you are losing more in fewer ticket sales. Pay bank $50.00; for each railroad you own.

20. You've added insulation to your water heater. Receive 2 energy chips.

21. You've added insulation to your home. Receive 5 energy chips.

22. You need to add more insulation to your home. Pay 4 energy chips.

- Additional Monopoly rules.
- Have the students play the game composed of groups of players numbering between four and six. After several groups have played the game over a period of time, a classroom discussion can be held on how they think the things they learned from the Monopoly game might apply in their real lives.

SPECIAL NOTES:

The students can be encouraged to invent new energy cards and add additional energy rules. The game can be used as suggested or as a learning center activity.

RULES:

Each player receives 25 energy chips at start of game.

If a player runs out of energy chips, an additional 10 chips may be purchased for $200.

Pay cost utilities for property

3 chips - each nonsolar home

6 chips - each nonsolar hotel

1 chip - each solar home

2 chips - each solar hotel

When a player lands on property owned by another, in addition to rent, player pays the following amount to the banks in surcharges on his utility bill costs.

$15.00 - nonsolar home

$ 5.00 - solar home

$30.00 - nonsolar hotel

$10.00 - solar hotel

To build a solar home/hotel, cost:

home - $200 + cost of house on card

hotel - $400 + cost of hotel on card

To build a solar hotel, the player must have built three solar homes. *(To signify a solar house/hotel, turn the house/hotel upside down.)

The game ends in one of the following ways:

1. at the end of an allotted time period
2. two players go bankrupt
3. two players lose all energy chips.

D_{1-VI}

CENTRALIZED AND DISTRIBUTED POWER SYSTEMS

D_{1-VI} (Approximate Grade Level #6)

OVERVIEW

Students will be given an understanding of the difference between a distributed power system (a system that produces energy where it is used) and a centralized power system (a system that produces power at a central location and then via a distribution system deliveries that power to where it is needed). The students then will investigate the power requirements of certain users (homes, factories, etc.) to see where the two types of power systems may appropriately be used. The study of the centralized power system will utilize the local utility company as a resource for information.

LEARNING OBJECTIVE

Student will gain a knowledge of the concepts of distributed and centralized power generation. By the preparation of a class report, this concept will be broadened into an understanding of the appropriate use of these two generation systems.

SPECIAL MATERIALS

No special materials are required for this lesson

VOCABULARY

Distributed, centralized, kilowatt-hour, power demand

EXTENSION EXERCISES

An assignment might be given to interested students to prepare a report for the class on the local utility company, such as its size, how much energy it could generate, ways it generates power (e.g., fossil fuels, hydroelectric), etc. The students could also find out what energy conservation programs the utility company is suggesting to their customers.

LESSON PLAN

Distributed Power Systems

A distributed power system is one where the power for a certain requirement is generated at or very near to the location of need. In principle, the requirement could be small or large. An example might be a remote location that has a small creek running through it and one that generates electricity at the site using a water wheel. In the future, there might be solar systems, such as a photovoltaic electrically generating system, that would generate the needed power for a home. The cells would be part of the roof, so that the incident sunlight that falls on the house could now be used to provide electricity. A major question with the last system is, "can the home generate enough power for all of its needs from only the sunlight that falls on it?" The power needs are not only for electricity but also in the power needed to heat water and keep the inside warm in winter and cool in summer.

Centralized Power Systems

A centralized power system has a large generating station that produces large amounts of power. This power is then sent over some sort of distribution system to the locations where it is needed. The utility company is an example of a centralized power system. Electricity is generated by large generating stations and then the electrical grid network is used to get it to homes and factories all over the service area of the company. The utility company also has some problems. With the distributed system, one has to be concerned that sufficient power can be produced to satisfy a total demand. The utility company must provide: The average power or base load its customers will usually need and any additional power that the customer may need (over and above the base load) only at certain times. This latter requirement is referred to as peak demand or peak load.

Base Load

This is the level of power the customers of the utility company will usually need. As a result, utility companies by law must provide base load generating plants that are efficient and low polluting.

Peak Demand Load

The peak load demand may occur for only a few hours a day at certain times of the year. For example, in Southern California, the peak demand is due to air conditioning loads during the summer months. Generally, the time of this demand is during the afternoon hours. These peak generating plants may not be as fuel efficient or as non-polluting as the base load plants which are continually in use. As a result, utility companies who are concerned with the increases in fuel prices should influence their customers to use appliances during non peak demand hours to minimize the cost of generating electricity.

Generally, the power requirements of a home are such that it could be possible to have sufficient energy from the sun fall on the roof to enable a solar system to produce all the energy requirements of the house. However, this may not be the case for the energy needs of a factory. Consequently, there will always be a need for some central power generation.

1. Have the students with the help of their parents, determine from old electric bills, the average daily kilowatt-hours of electrical energy their home uses. If there are few major electrical appliances in the home, the figure may be as low as 10 KW-HR. It could be much higher.

2. Again, with the help of their parents have the students estimate the area of their roofs.

3. Assume that a photovoltaic system is 15% efficient. That is, if 100 watts of solar energy fall on our solar system, 15 watts will be converted directly into electricity.

4. Also assume that about one kilowatt per square meter falls on the roof of their home, and that on the average, this energy level lasts about six hours each day.

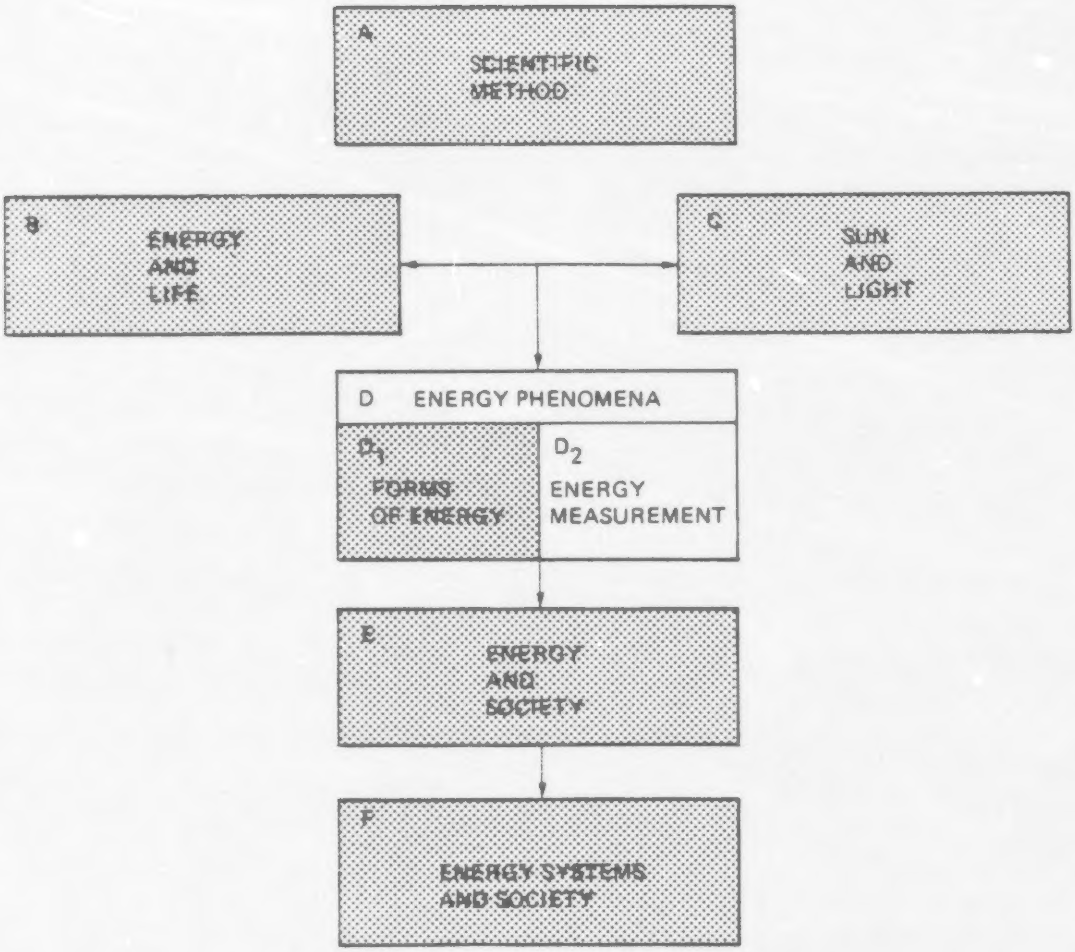
5. Consequently, if the students took their total roof area, in square meters, multiplied that figure by one (kilowatts falls solar energy/meter square), then by 0.15 (15% efficiency) and then by 6 (six hour per day), they will get an estimate of the maximum number of kilowatt-hours their home solar energy electric system could produce. If some of their roofs face north, are shaded, etc., this figure may be much too generous.

6. Have the students make this estimate for their homes. How many of them could actually have a chance of producing most of their electrical needs from a distributed power system?

7. If all the homes were in a cluster, what would be the size of the local power system that would service them all have to be?

8. Have the students also discuss what they would do during cloudy or rainy weather when the sun is not visible.

9. Have some of the students contact the local utility company. Obtain from them the average base and peak load demands they usually have. If possible, have the students find out how much electricity a local factory might generally use. How big a solar system would be needed to provide that amount of electrical energy?


A
SCIENTIFIC
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B
ENERGY
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D ENERGY PHENOMENA
D_1
FORMS
OF ENERGY
D_2
ENERGY
MEASUREMENT
E
ENERGY
AND
SOCIETY
F
ENERGY SYSTEMS
AND SOCIETY

D_2 ENERGY MEASUREMENTS

Energy is the ability to do work, to move something. Types of energy that can make things move include heat, light, and electricity. We can experience some sense of energy by seeing, touching, or hearing, but how can we measure this energy?

First of all, we must adopt some standard to measure energy in its various forms that most everyone in the world can agree on. Once we have agreed to some standard, we can produce devices called gauges or scales set by these standards. With these, we can achieve an accurate measurement of energy and what energy can do for us. Fortunately the arguing about what standard will be used has already been done for us.

To begin with, let's look at measuring temperature. Temperature does not measure heat. In fact, temperature measures the average kinetic energy of particles or molecules contained in a substance (kinetic energy is energy of particles in motion). Then the higher average kinetic energy of the particles of a substance, the higher the temperature. The temperature difference or change in temperature of a substance, represents heat put into or taken out of the substance. Temperature is measured by using a thermometer. With a thermometer, we can determine what temperatures are hot and what are cold. What goes on inside the thermometer? Most common thermometers consist of a liquid substance (i.e. alcohol, mercury ...) enclosed in a glass tube (see Figure D-5). Mercury, like most other substances, expands when it is heated. Then, when it is hot, the mercury rises higher in the tube giving higher temperatures and when it is cold, the mercury is lower in the tube giving low temperatures. Standards used in measuring temperature are usually in degrees, Fahrenheit (°F) or degrees celsius (°C).

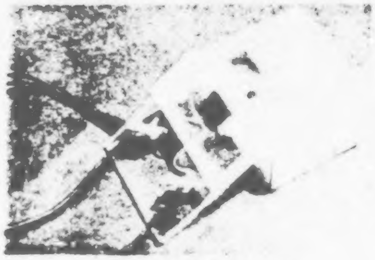
Devices that are used widely in measuring electricity are ammeters and voltmeters. These seemingly magical devices tell us much about how electricity works. On the front of these devices is a pointer and scale as shown (Figure D-9). What happens when the ammeter is connected to wiring is, it looks for current flowing in the wire. Current is the rate of flow of tiny charges called electrons. When a current is found, the pointer (arrow) mysteriously moves. What actually happens is, the current flowing in the wire called amperes or milliamperes (amps or milliamps for short). One milliamp is 1/1000 of an amp.

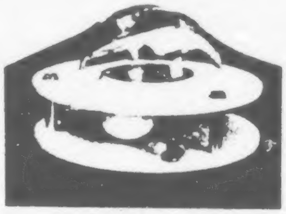
The secret is this magic trick only works if the ammeter is connected properly. Proper connection is in series or in line with the wire so current flow through the meter.

Another device used in measuring electricity, is the voltmeter. The voltmeter works very much in the same magical way as the ammeter, except it is connected differently and measures voltage. Voltage may be thought of as a way to measure stored energy as in a battery. Voltage is measured in parallel or along side a wire and tells us how much energy is being stored or used in between the ends of the wire.

An important relationship that deals with voltage and current is power. Power is the amount of energy that can be used per unit time. The more voltage or current or both that we have, the more power we have and the more things we can run.

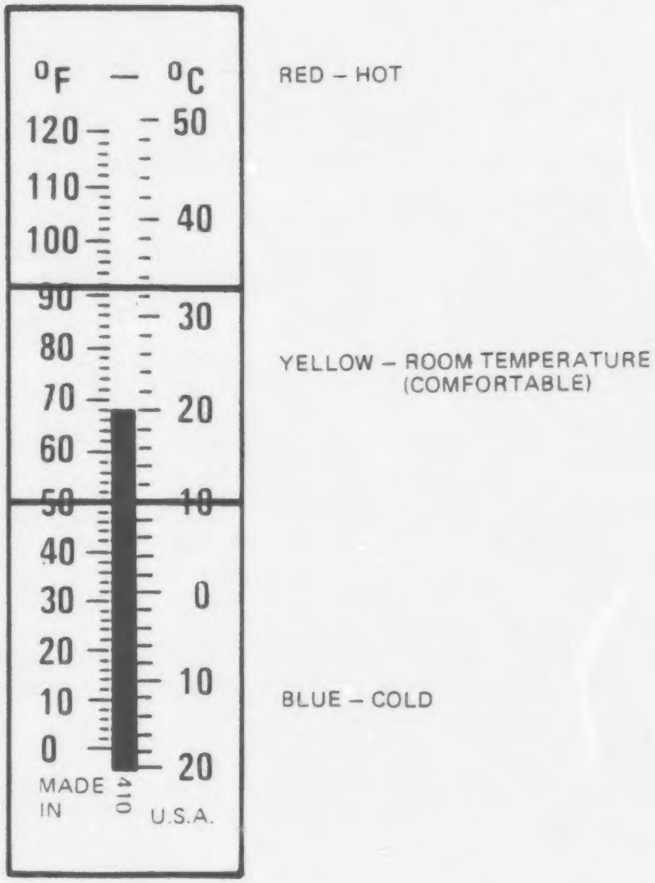
The ammeter is used to measure current. We can also use it to find the isolation of an area by connecting the meter to a silicon photo cell. The pyranometer is a device that converts solar energy directly into electrical energy. This helps us to find out how much sunlight is striking the surrounding area.


SILICON PHOTO CELL
AND AMPMETER


PYRANOMETER

Terms:

1. Insolation - The solar radiation reaching the earth or the rate of delivery of such radiation per unit area surface.
2. Pyranometer- Is a device that converts solar energy directly into electrical energy.
3. Ammeter - A device used to measure current flowing in a wire.
4. Current - That energy flowing through wires measured in amperes.
5. Voltage - The difference in electrical potential or charge between two points.
6. Power - The rate at which work can be done, the more power available, the more work can be done.
7. Resistance - The opposition to an electric current.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10
0
10
20
MADE IN
410
U.S.A.
RED – HOT
YELLOW – ROOM TEMPERATURE (COMFORTABLE)
BLUE – COLD

Figure D-5. The Thermometer Shown at Room Temperature

MEASUREMENT OF TEMPERATURE

A common device used in the measurement of temperature may be the thermometer. Most thermometers consist of a thin glass tube with a small bulb at one end and a scale along the tube. Mercury is contained in the bulb which may travel up or down the tube depending on outside temperatures. Different colors may be placed along the tubes to represent different temperature ranges such as hot, room temperature, and cold. Closer temperature measurement can be seen by reading the scale. Temperature does not measure energy directly but is necessary to measure changes in energy such as heat. Also, the choice of a temperature scale is arbitrary. That is, any number of linear units may be picked between known temperatures, such as the freezing point and boiling point of water. Since the freezing point and boiling point of water are constant, we can pick a freezing point at 32° and a boiling point 212°. This scale is referred to as the Fahrenheit scale. A simple scale may be to choose zero (0) as the freezing point of water and 100 as the boiling point. This is called the Celsius scale. Any amount of linear units can be given. The lowest temperature that any substance can reach is -459°F (or -270°C (scales such as the Rankine and Kelvin pick this point as zero).

TEMPERATURE (GAUGE)

A thermometer is a device which tells us what things are hot and what things are cold. The different colors that we see on our gauge represents hot, room temperature and cold. At what temperature is the gauge reading now? It should be at room temperature. What color should the thermometer be when placed in boiling water? Ice? Temperature can be measured by looking at the top of the dark line on the thermometer.

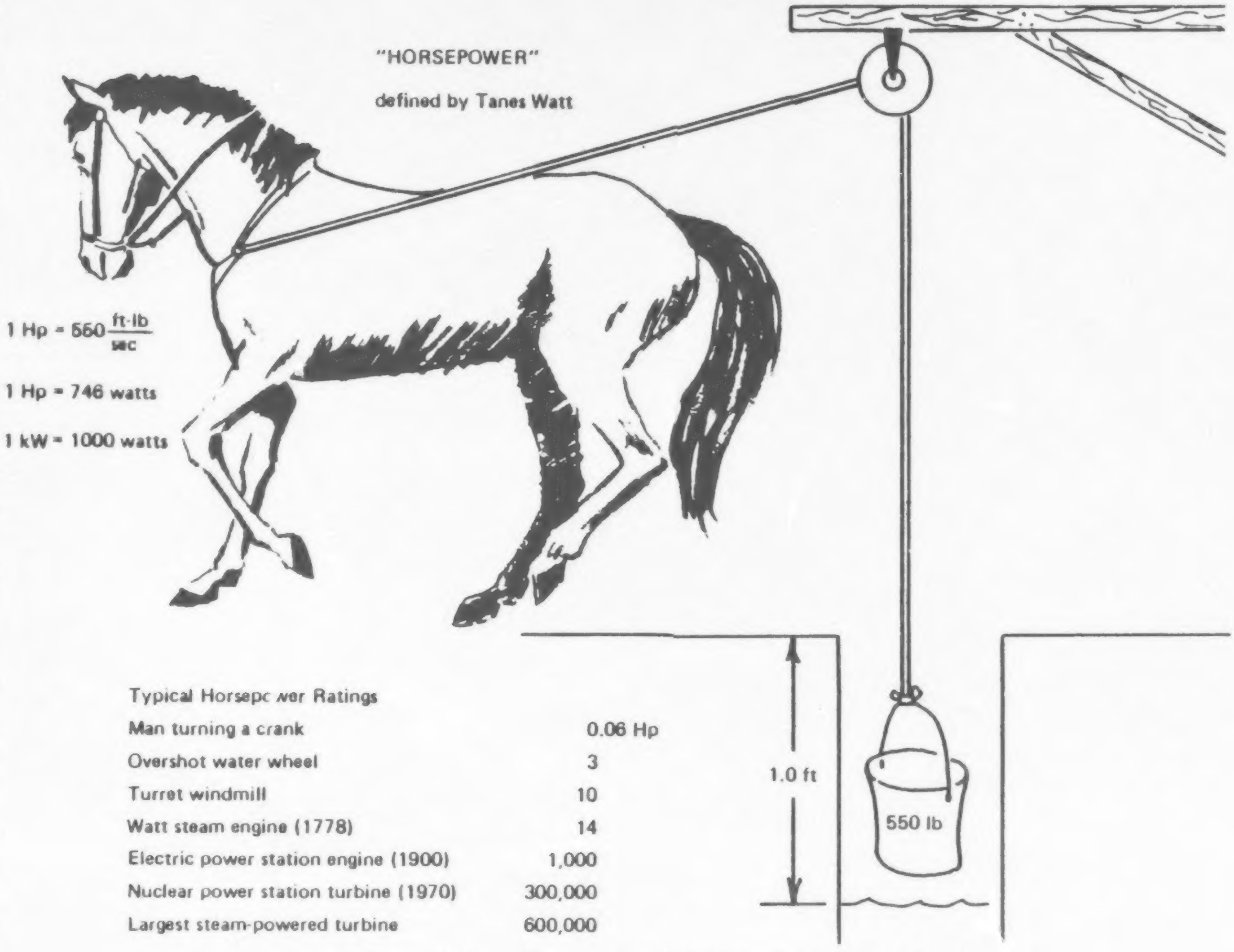
MEASUREMENT OF ENERGY

Up until the past few hundred years, humans principal source of energy for doing work was the human and animal power and simple machines. Of course, humans used such devices as windmills, water wheels, and sailing ships to replace human muscles; but the forces used in driving these machines, wind and water, were unreliable. Sudden droughts or long periods of calm weather would limit their use. Muscle power was adequate in early stages of human existence to provide the needs for survival. As time elapsed, the control and use of energy increased as man began to domesticate and use animals. Since these early beginnings, the search for other forms of energy has continued up to and including the present.

Beginning in the eighteenth century, the need of reliable energy sources for performing mans work resulted in machines built to work harder and faster than human muscle. During this age of machines and industrialization, man began to realize a need for measuring energy. In other words, how much energy was required to do a certain amount of work. For example, we might describe the amount of oxen needed to pull a cart as "oxen power". No definite universal method of measuring power had been accepted and no attempt to correlate power with definite physical qualities such as weight and time had been developed. In 1800, James Watt, the inventor of the steam engine, developed a system for measuring energy called "horse-power". Horsepower, as defined by James Watt, was the power a strong horse could deliver, which is equivalent to lifting 550 pounds one foot in one second (see Figure D-6). In terms of electrical or energy from moving electrons, one horsepower is equal to 74 watts named after James Watt.

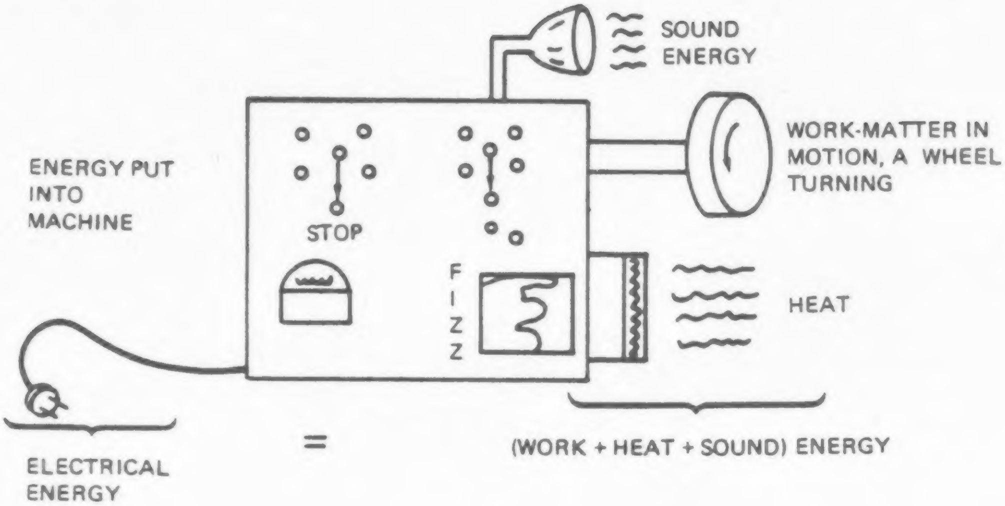
It was not necessary for James Watt to use the horse to develop a method of measuring power. Any animal or machine capable of doing work could have been used; all of which could have been used to develop some universal method of measuring power. Horsepower is widely accepted today in measuring the power of machines and engines.

Through the development of machines and engines, humans have learned much about energy and work. Power is measured as the rate at which energy is being used, then machines with more power can produce energy or do work faster. It has been found that one form of energy can be changed into a number of others by using a machine. It has also been found that in using an engine, work output is less than energy input. Work or energy available to move things is never greater than the energy put into a machine. Where has this energy gone? In most cases, this energy has been lost as heat caused by friction of the moving parts of the machine. It has been found that making machines with fewer moving parts, more useful work can be done. Scientists have noticed that by adding up all the energy put out by a machine, work, heat, sound or other forms is exactly equal to the energy put into the machine. This is called the conservation of energy (Figure D-7).


"HORSEPOWER"
defined by Tanes Watt
1 Hp = 550 $\frac{\text{ft-lb}}{\text{sec}}$
1 Hp = 746 watts
1 kW = 1000 watts
1.0 ft
550 lb

Typical Horsepc wer Ratings	
Man turning a crank	0.06 Hp
Overshot water wheel	3
Turret windmill	10
Watt steam engine (1778)	14
Electric power station engine (1900)	1,000
Nuclear power station turbine (1970)	300,000
Largest steam-powered turbine	600,000

Figure D-6. "Horsepower" Defined by James Watt



SOUND ENERGY
WORK-MATTER IN MOTION, A WHEEL TURNING
ENERGY PUT INTO MACHINE
STOP
FIZZ
HEAT
ELECTRICAL ENERGY
=
(WORK + HEAT + SOUND) ENERGY

Figure D-7. The Principal of the Conservation (Many Phenomena Studied by Scientists Can be Explained by this Principle).

D_{2-K}

ENERGY MEASUREMENTS

Unit D_{2-K} (Approximate Grade Level Kindergarten)

OVERVIEW

Through class discussion, the concepts of big and small will be discussed and defined. Comparisons will be made, and the class will engage in some basic measuring exercises.

LEARNING OBJECTIVE

Students demonstrate an awareness of the basic concepts of measurement through participation in a series of classroom experiences and experiment.

EVALUATION

As we have discussed previously, engaged behavior can be evaluated by teacher observation of student involvement. Evaluation sheets are enclosed (see Figure D-9).

SPECIAL MATERIALS

- Specially constructed tri-color thermometer.

VOCABULARY

Measure, temperature, bigger, smaller, hotter, colder, faster, slower, heavier, lighter.

EXTENSION EXERCISES

These are implied in the context of the lesson.

LESSON PLAN

1. Ask the class to think of the biggest thing they can. Take a suggestion. Ask if someone can think of something which is bigger than the suggested item. Then, ask if someone can think of something bigger than the 2nd suggestion. Continue the process until (1) the class seems to be fading, or until (2) no one can think of a bigger item.

2. Do the same things for the smallest things. (see 1 above)

3. Ask the class how we know that the "biggest thing we've thought of is bigger than the smallest thing". Come up with the idea of measurement.

4. Begin to measure things:
    a. See who is the tallest in the class.
    b. See who can run the fastest.
    c. Who can jump the farthest.

    (Do things that can be measured without units).

5. Introduce a thermometer as a tool to measure how hot or cold something is. (If needed, explain that the higher up the liquid goes, the hotter something is.)

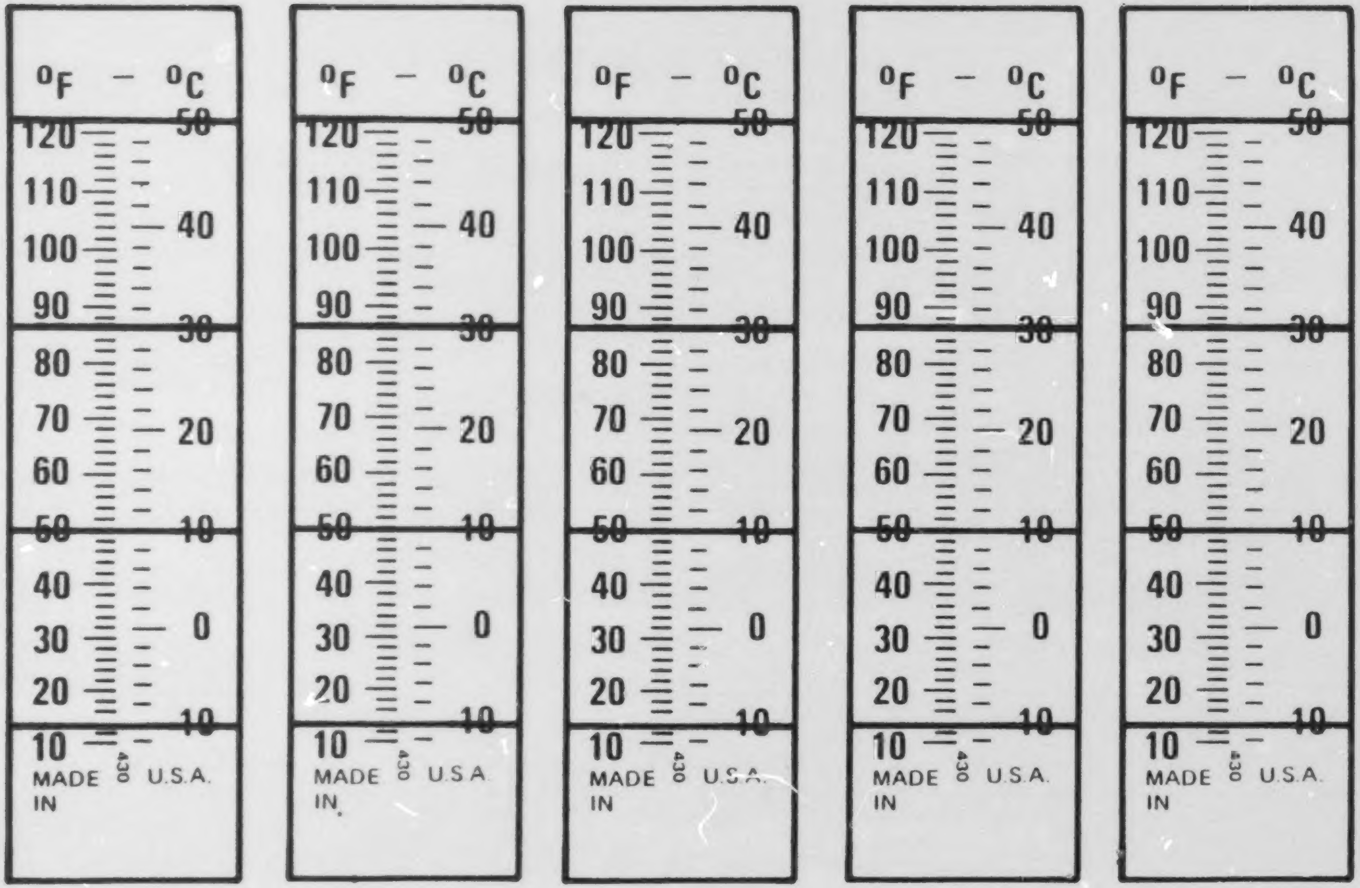
6. Measure hot and cold water, etc. with the thermometer.

7. Review the concepts of the biggest, farthest, tallest, etc.

8. Have the class find other things to measure.

SPECIAL NOTES

In place of the specially constructed thermometer (Figure D-8) you may use a pool thermometer or other type of thermometer suitable for using in liquids and merely wrap it with colored tape or cellophane. Any similar device may be used.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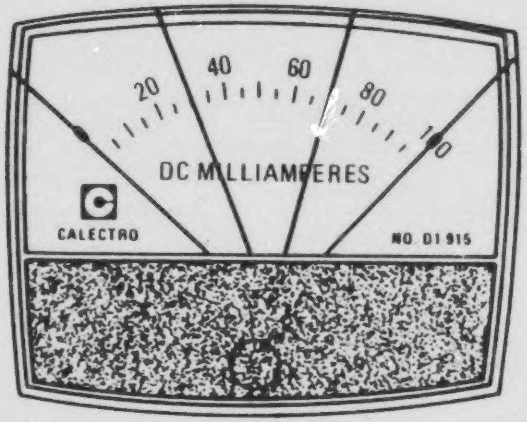
430
U.S.A.

1. ____________ 2. ____________ 3. ____________ 4. ____________ 5. ____________

Figure D-8. Temperature Record Sheet

METER RECORD SHEET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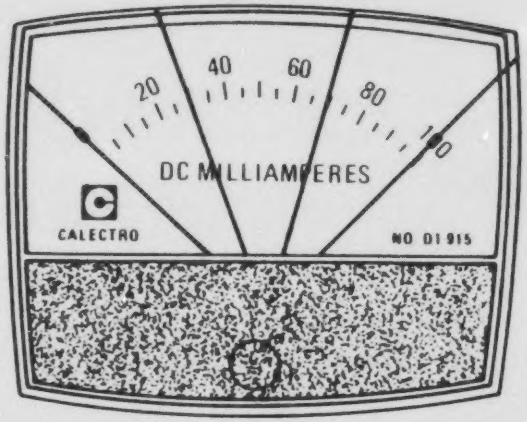
DC MILLIAMPERES
CALECTRO
NO. D1915

1. ____________________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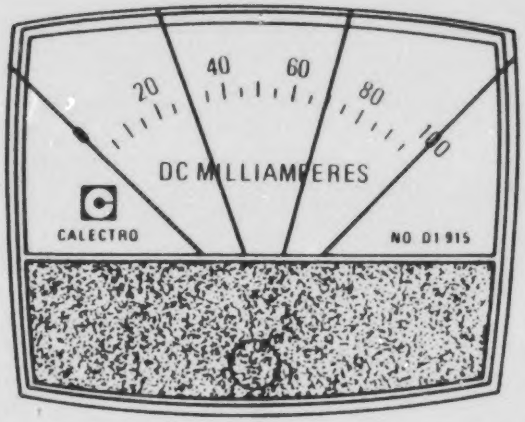
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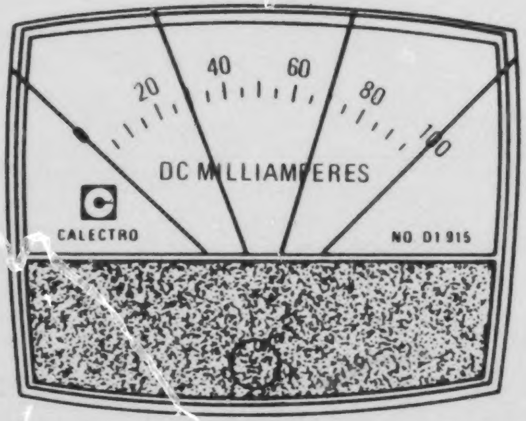
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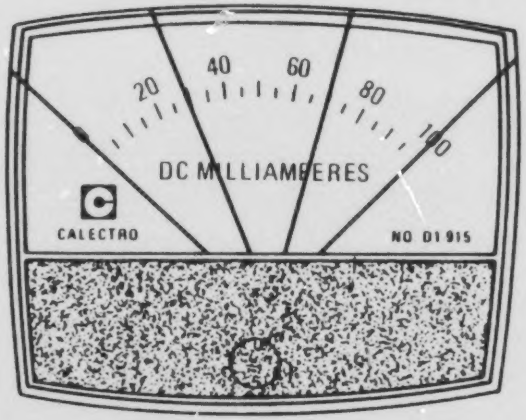
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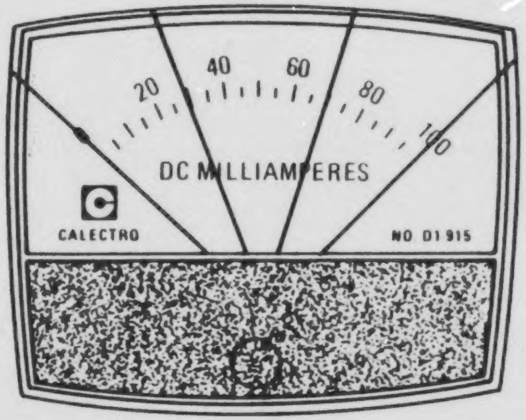
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CALECTRO
NO. D1915

6. ____________________

Figure D-9. Ammeter Record Sheet

ENERGY MEASUREMENTS

Unit D_{2-I} (Approximate Grade Level #1)

OVERVIEW

Students are introduced to the basic measurement tools: the ruler, the scale, the thermometer and the radiometer. They are shown what each of these tools measures, how they are used, and are given a chance to use each tool to perform measurements.

LEARNING OBJECTIVE

The first grade students will demonstrate an ability to perform basic measurement tasks applying an understanding of the functioning of the following tools: ruler, thermometer, scale, and radiometer. This will be evaluated through the written records kept of each measurement task.

EVALUATION

The teacher will need to prepare special measurement work/record sheets for each kind of measurement. Those for the ruler and for the scale will need to be developed by the teacher. Successes in completion will indicate mastery of this skill area.

SPECIAL MATERIALS

- A simple ruler, preferrably in centimeters.
- A simple scale for weighing things, such as a postage scale or a scale for a fisherman to measure the weight of his catch. Preferrably in grams.
- Specially prepared tri-colored thermometer (see special notes for substitution).
- Simple radiometer (see special notes for substitution).

VOCABULARY

Length, weight, temperature, brightness, thermometer, radiometer.

EXTENSION EXERCISES

Additional measuring experiences.

SPECIAL NOTES

In place of the specially constructed thermometer, you may use a pool thermometer or other type of thermometer suitable for using in liquids and merely warp it with colored tape or cellophane. Any similar device may be used.

The students could make their own rulers inventing any unit of length they wish, for example, length of the tip of their finger, the width of their nose, the width of their hand, and so forth, using that basic unit of measure. Make and construct rulers out of heavy paper, color them and keep them for use for later exercises. In addition to using the special radiometers, teachers can use a photographic light meter by constructing a colored cellophane overlay, over the needle location and achieve similar results.

LESSON PLAN

This lesson will work best in learning centers. It can be adapted to other formats relatively easily, but the more direct contacts a student has with the actual tools, the more successful one experience will be.

CENTER 1. MEASURING LENGTH

1. There should be some rulers.
2. There should be a series of objects to measure.

3. There should be a worksheet which has the tracings of the objects to be measured, so that the student can indicate the lengths on the given sides of the object.

CENTER 2. MEASURING WEIGHT

1. There should be either a postal or kitchen scale.
2. There should be a worksheet which has a series of exact copies of the scale face (both should be color coded if possible).
3. There should be a aseries of objects to be measured.

CENTER 3. MEASURING TEMPERATURE

1. There should be thermometers.
2. There should be thermometer measuring sheets (included).
3. There should be a series of hot and cold things to measure, (ice water, regular water, hot water, etc.).

CENTER 4. MEASURING BRIGHTNESS

1. There should be radiometers.
2. Radiometer worksheets (included) (Figure D-9).
3. Several light sources (flashlight, lamp, the room, a projector, etc.) which can be measured.

1. Review the concept of measurement.
2. Introduce the tools and demonstrate how they are to be used.
3. Introduce the centers and the things in them.
4. Break the class into four groups and have each work in one center.
5. Rotate the class through all four centers.
6. This activity should be repeated more than once.

ENERGY MEASUREMENTS

Unit D_{2-II} (Approximate Grade Level #2)

OVERVIEW

This lesson has two parts: (1) is a rerunning of lesson D_{2-I} – which gives the students a direct experience with measuring; (2) a card sort deck which allows the students to match tools to measuring tasks.

OBJECTIVES

1. The students will demonstrate an ability to perform basic measurement tasks applying an understanding of the functioning of the following tools: ruler, thermometer, scale, and radiometer.
2. The students will demonstrate application of measuring skills by matching measuring tools with taks through the use of a manipulative card deck.

EVALUATION

Evaluation for the first objective will match that of D_{2-I}. Evaluation ror the second objective will utilize teacher observation of individual students' manipulation of the card decks as we have previously done.

SPECIAL MATERIALS

- A simple ruler, preferrably in centimeters.
- A simple scale for weighing things, such as a postage scale or a scale for a fisherman to measure the weight of his catch. Preferrably in grams.
- Specially prepared tri-colored thermometer.

- Simple radiometer.
- Special Card Deck (Fig. D-11).

VOCABULARY

Length, weight, temperature, brightness, thermometer, radiometer.

EXTENSION EXERCISES

Additional experiences with measurement.

LESSON PLAN

1. Redo the D_{2-1} lesson.
2. Pass out card decks to students. Have them cut out the decks if necessary.
3. Have them sort out the four measuring tools from the deck.
4. Have them sort out all the things that can be measured with a scale.
5. Repeat for each of the tools.
6. Have them play a game of gin, where the packs of three are made by combining things that can be measured with the same tools.
7. Have them invent their own card game.

LESSON PLAN

This lesson will work best in learning centers. It can be adapted to other formats relatively easily, but the more direct contact a student has with the actual tools, the more successful the experience will be.

CENTER 1. MEASURING LENGTH

1. There should be rulers.
2. There should be a series of objects to measure.
3. There should be a worksheet which has the tracings of the objects to be measured, so that the student can indicate the lengths on the given sides of the object.

CENTER 2. MEASURING WEIGHT

1. There should be either a postal or a kitchen scale.
2. There should be a worksheet which has a series of exact copies of the scale face (both should be color coded if possible).
3. There should be a series of objects to be measured.

CENTER 3. MEASURING TEMPERATURE

1. There should be thermometers (see the special note).
2. There should be thermometer measuring sheets (included).
3. There should be a series of hot and cold things to measure (ice water, regular water, hot water, etc.).

CENTER 4. MEASURING BRIGHTNESS

1. There should be radiometers (see note).
2. Radiometer worksheets (included).
3. Several light sources (flashlight, lamp, the room, a projector, etc.) which can be measured.

LESSON PLAN

1. Review the concept of measurement.
2. Introduce the tools and demonstrate how they are to be used.
3. Introduce the centers and the things in them.
4. Break the class into four groups and have each work in one center.
5. Rotate the class through all four centers.
6. This activity should be repeated more than once.

SPECIAL NOTES

The teacher is referred to special notes in unit D_{2-K} of this section in relation to making substitute thermometers. The students could make their own rulers inventing any unit of length they wish, for example, length of the tip of their finger, the width of their nose, the width of their hand, and so forth, using that basic unit of measure. Make and construct rulers out of heavy paper, color them and keep them for use for later exercies. In addition to using the special radiometers, teachers can use a photographic light meter by constructing a colored cellophane overlay, over the needle location and achieve similar results.

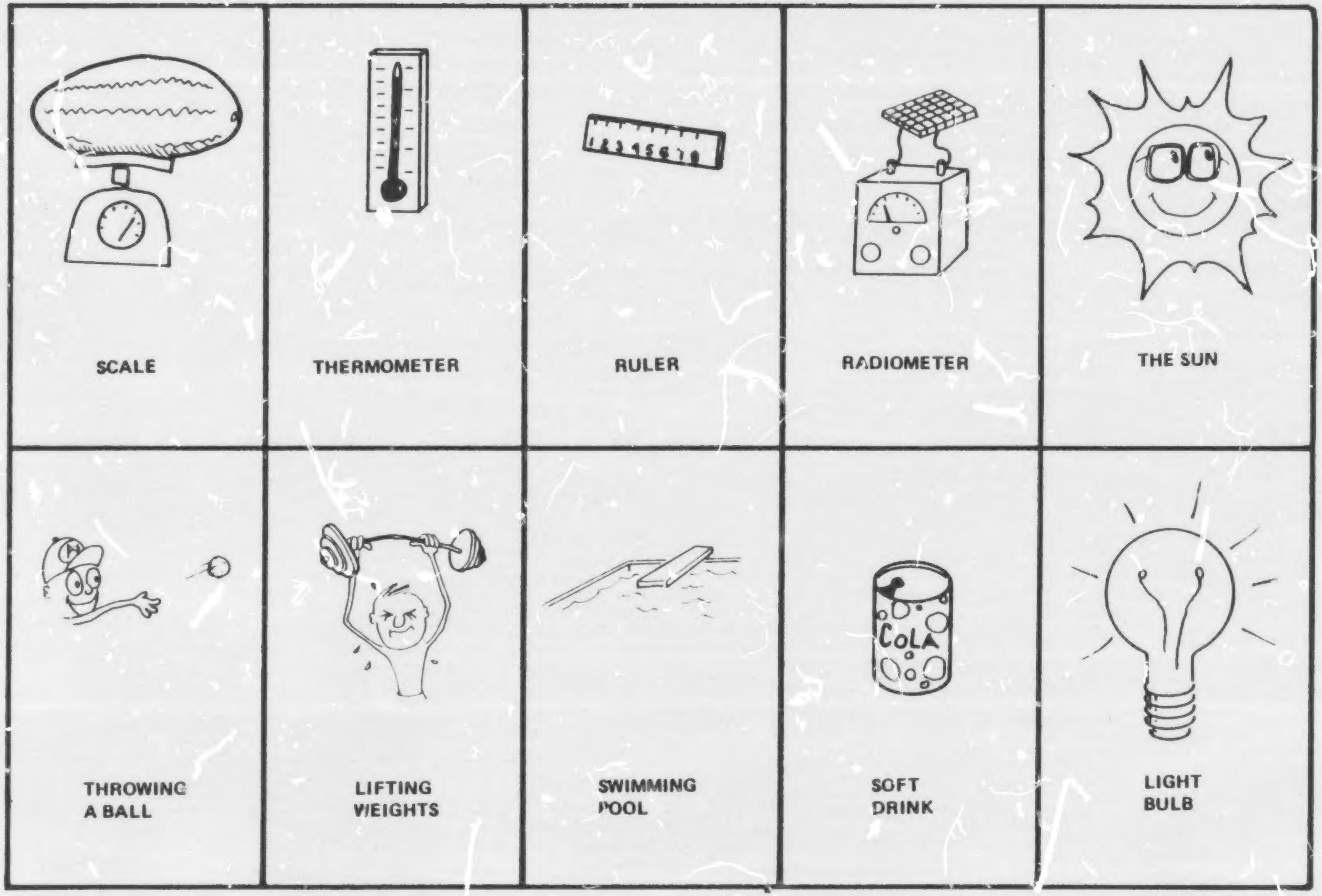
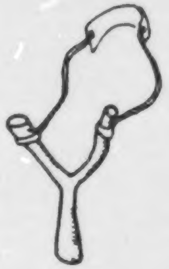
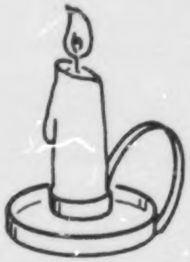

SCALE
THERMOMETER
RULER
12345678
RADIOMETER
THE SUN
THROWING A BALL
LIFTING WEIGHTS
SWIMMING POOL
SOFT DRINK
COLA
LIGHT BULB

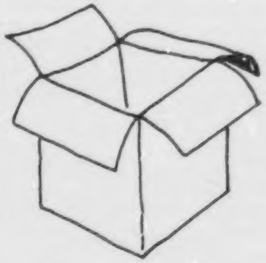
Figure D-11. Tools and Measuring Devices - Sample Card Decks



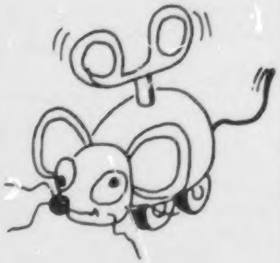
SLING SHOT



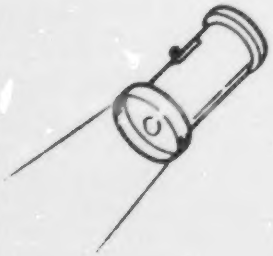
CANDLE



BOX



TOY MOUSE



FLASH-LIGHT

Figure D-11. (Continued)

$D_{2\text{-}III}$

ENERGY MEASUREMENTS

Unit $D_{2\text{-}III}$ (Approximate Grade Level #3)

OVERVIEW

Many of the solar devices introduced in earlier lessons are now investigated scientifically using measuring tools. These experiments include comparing water left in the sun in a black jar, a clear jar, a jar wrapped with aluminum foil. Light measurements are made in conjunction with direct exposure to the sun and by using concentrated sunlight with additional reflecting surfaces. The students are encouraged to improvise other experiments. All the experiments are carried out using the scientific method where the problem is first defined, a prediction is made of the outcome, an experimental program is carried out, results observed, and then comparisons are made between the predictions and the experimental results.

LEARNING OBJECTIVE

The student will apply the scientific method and basic measurement skills to a reflection/absorption experiment as demonstrated by the completion of a "Lab Report".

EVALUATION

Post lesson evaluation can be accomplished by observing how well the students have worked with their special scientific data sheet.

SPECIAL MATERIALS

- Special temperature and radiometer data sheets.
- Scientific method record sheet.
- Special thermometer (see special notes for substitution of equipment.
- Three similar wide mouth glass jars.
- Some black poster paint.
- Some aluminum foil.
- Two small hand mirrors.
- A piece of black construction paper.

VOCABULARY

Scientific method, temperature, light energy, concentration, reflection, absorption, prediction, experimentation, observation.

LESSON PLAN

1. Present the idea to the class that some things absorb energy and others reflect energy away. Take the small hand mirror and reflect the light from one of the light bulbs or open windows against the wall. Discuss with the students how light hit the mirror and was reflected away onto the wall.

2. Take a piece of black construction paper, hold it next to the mirror at the same angle and show that there is no reflection on the wall. Pose the question to the students why is this so? This is because black absorbs the light energy and the mirror reflects it all the way.

3. Pose the question now to the students, what if we were to take the three bottles, paint one of them black on the outside, wrap one of them with aluminum foil, leave one of them alone and then measure the temperature inside. Which jar do they think would be the hottest, which jar the coolest, which one in between?

4. Have each team of 4-6 students make a special scientific method record sheet, have them draw three bottles, one painted black, one clear, and one silver. Have them make note of three temperatures that they will expect, a temperature for each jar. Have them paint one of the bottles on the outside with the black poster paint, wrap another bottle with the foil paper, leave the third bottle alone. Fill them all with the water and put them out in the sunlight.

5. Every 15 minutes or so have a particular "research team" of students composed of 2 to 6 individuals go outside and make measurements of their three jars. Record these measurements on the blackboard over a period of time.

6. Compare the results obtained with the predictions and see which students predicted most closely the temperatures.

SPECIAL NOTES

No special thermometer is required necessarily in this case, any thermometer that can be used in liquids and will fit inside the jar will suffice. The special colored thermometer has also been designed to do this work. The radiometer using a small silicon cell and one hundred milliamp can be substituted by any similar combination of devices (c.f., the Applications Section).

The hot dog cooker can be utilized, illustrating how the curved surface of the reflection area concentrated the sunlight onto the hot dog and thereby cooks it. The students could actually attempt measurements by putting the hot dog cooker in the sunlight and then putting the silicon cell near focus, i.e., where the wooden stick is. Rotate the cell up and down to see how the measurements might change and compare the results with a direct reading from the sun.

INSOLATION (SUNLIGHT) AND TEMPERATURE MEASUREMENTS

Unit $D_{2\text{-}IV}$ (Approximate Grade Level #4)

OVERVIEW

Using a silicon cell and meter, the class as a whole will participate in plotting the light energy falling on the ground over the school day. Additionally, temperature measurement (made in the shade) will also be recorded for the school day. These measurements will emphasize material previously covered in dealing with the spread of energy over a surface area when the light source (in this case, the sun) is at angles and normal to the surface.

LEARNING OBJECTIVES

Students will develop techniques for making simple insolation (sunlight), and temperature measurements over a classroom day.

EVALUATION

Students will develop skills in the use of the silicon cell and meter and thermometer in making insolation and temperature measurements. The students will comprehend and understand why the plot of sunlight over the day follows the particular curve that will be developed.

SPECIAL MATERIALS

- Silicon cell meter (see information on special energy teaching apparatus developed for this curriculum in applications section).
- A thermometer.

VOCABULARY

Insolation, temperature, peak value, plotting, graphs.

LESSON PLAN

The teacher will remind the students of the material previously learned in dealing with the energy density on a surface when the light source is not directly above it, but rather at some angle. The teacher will remind the students that when the light source was at a low angle, the light falling on the surface was quite dim in comparison to when the light source was directly overhead (e.g., the flashlight and paper experiment, or the flashlight and tilting card experiment, or the heat lamp and tilting hand experiment.)

The teacher will pose the question, "Is there any similar situation between the earth's surface and the sun?" The teacher will then suggest that the students carry out an experiment to determine the exact effect.

ACTIVITIES

NOTE: It is suggested that this lesson be carried out over a two day period. The first day, the students will be introduced to the subject and familiarize themselves with the apparatus. They will also have some discussion about the project. The second day, the program can start first thing in the morning and be carried out periodically throughout the day.

First day:

- The students will carry on a discussion of how they think the light energy (insolation) striking the surface of the earth varies over the day. This conversation can also include how they think the temperature may vary during the day.
- If not previously done in other parts of their course work, the students can now be introduced to the concept pf plotting a graph (Figure D-10).

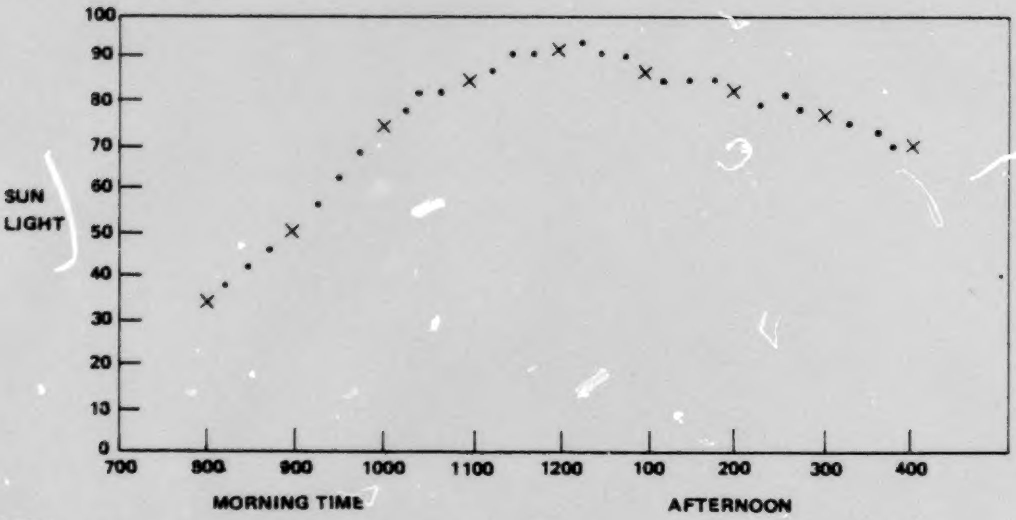


Figure D-10. Graph of Sunlight Intensity (Insulations) During the Day

- Toward the end of the first day, have the students construct on part of the blackboard a layout to make their measurements on during the following day. The vertical axis will cover numbers between 0 and 100. (100 should be about the maximum reading obtained during the hottest part of the day). The horizontal axis will cover the time over the school day. The students should be able to resolve about 15 minutes time increments over the day (again see illustration to right).

- Have the students construct a second graph for their temperature recording. The vertical axis should cover the temperature span expected over the day (this will depend on the particular location and season of the year), and again the horizontal axis should allow plotting where periods as close as 15 minutes be easily resolved.

- The students should be introduced to the cell and meter. The red wire is attached to the positive terminal of the meter and the positive side of the solar cell (the back side or fully silvered side of the cell). The black wire is attached to the negative side of the meter and the negative side of the solar cell (the front of the solar cell with the silver grid network over dark blue background).

- Have the students take the meter and point it towards either the sun, a bright lightbulb, or the light coming from a movie or slide projector.

- Have the students make readings on the meter, and as they make the readings, have them tilt the cell to and from the light source. Have the students note the changes in meter readings.

- Show the students the thermometer (the color temp thermometer with color overlays removed will be a fine choice).

Second day:

- A suggested approach will be to have each student participate in the measurement process. At 15 minutes to 30 minute intervals a student will go outside the classroom to a particular preselected area that is clear from shadowing from any obstruction, lay the solar cell flat on the ground (i.e., cell negative side will be facing directly upward) and have the student note the reading on the ammeter.

- The student will return to the class and plot the result on the graph that was prepared the preceeding day.

- As the day goes on and the graph slowly builds up, the teacher can periodically call attention to the information being plotted and briefly discuss with the students; such things as the rate of increase or decrease in insolation, the point in time when the maximum or peak reading occurs, or any other significant information that may be determined from the graph.

- The same student or partner can go out at the same time and make a temperature measurement. This temperature measurement can also be recorded in the same way on the previously prepared graph and similar discussions can be carried out.

  NOTE: The graph obtained from the insolation measurement on a clear day should be what is known as a "cosine curve". This curve will be similar to the illustration. Figure D-10. The greatest insolation should occur roughly at noon.

- Any changes in the smooth development of the curve, such as clouds, shadows that might come in from surrounding trees, and etc., should be observed and discussed during classroom discussions.

SPECIAL NOTES

This experiment can be carried on for more than one day if desired by the teacher. Obviously, best results will be obtained during clear weather. Contrast can be shown, however, if clear day results are compared to cloudy day results. The graph from the blackboard can be copied on graph paper by the students, or the data may be recorded on a large piece of graph paper if available or blank paper rather than the blackboard.

The experiment can also be carried out with the solar energy cell placed on some sort of device to tilt it in a particular direction, e.g., which simulates the tilt of a solar collector placed on a roof. The students may observe the difference in the sun's energy falling on the tilted surface in contrast to what falls on the horizontal surface.

D_{2-V}

DETAILED ENERGY MEASUREMENTS

Unit D_{2-V} (Approximate Grade Level #5)

OVERVIEW

Over a period of several days, students make a series of measurements of sunlight and temperature to see the variation of these parameters. As an optional, the sunstor battery charger can be used to construct a "state of the sunlight" to obtain a continual class visual representation of the sun's incident energy on the surface of the earth. Students will graph and plot the data they are collecting.

LEARNING OBJECTIVES

The students will increase their ability to make energy measurements, particularly insolation and temperature measurements. Other skill levels such as required in graphing and curve drawing will also be strengthened.

EVALUATION

The students will obtain an understanding of the way solar energy varies on a surface over the day. Students will demonstrate a knowledge of how to produce and draw graphs.

SPECIAL MATERIALS

- A thermometer (color temp, thermometer optional).
- Solar cell and meter.
- Sunstor battery charger (optional).

VOCABULARY

Insolation, Temperature, Graph.

LESSON PLAN

The teacher will ask the class how the sun's energy varies over several days on the ground. Is the energy constant all day long on the ground, or does the energy have some maximum value at some particular time of the day? Will one day be the same as the next? Will a tilted solar collector receive more solar energy than a collector laid flat, i.e., horizontal plane? The teacher will suggest to the class that they actually do a "scientific experiment" to find answers to these questions.

ACTIVITIES

- The suggested format for the lesson is the following: (Refer to lesson D_{2-IV}.

- A large graph can either be drawn on the blackboard or on a piece of paper. Along the horizontal axis of the graph will be time increments. The time should cover the span from the opening of school to the close of school, and one should be able to estimate periods as short as 15 minutes. On the vertical axis will be drawn numbers from 0 - 100 (corresponding to the 0 to 100 reading on the meter associated with the silicon photo cell). Periodically, say every 15 to 30 minutes, a student will go outside and measure the meter reading with the photocell lying flat on a particular, unobstructed piece of ground. That student can then return to the room and put his/her reading on the graph.

- Periodically, as the graph fills, the teacher can call attention to the data to that point and pose the question to the particular "research team", "How will the curve continue to build up?"

- Simultaneously with the insolation measurement, students can also make temperature measurements. As an option, the students can draw a second graph to record these measurements. Again the horizontal axis will be for the time and in this case, the vertical axis will cover the necessary temperature range for the day.

- The maximum insolation measurement should occur approximately at noon time. Precceding that maximum reading and following it, the sun's energy will dissipate. This is due to the fact the actual solar intensity at low angles of the sun is spread out over greater surfaces (cosine effect, refer to lesson C_{IV}). Also as the sun approaches the horizon, the solar energy must pass through greater and greater amounts of the atmosphere. The air absorbs and scatters the solar energy.

- This particular student experiment can be obtained for a single day of good, clear weather and a single day of cloudy weather or done over a period of several continuous days.

- Make special notes of changes in solar intensity due to cloud cover or to the sun passing behind objects such as trees.

- The teacher is referred to the background material that came with the sunstor battery charger. As an optional feature, the sunstor can be used as a small solar collector and lightbulb to develop the state of the sunlight as discussed in the background material.

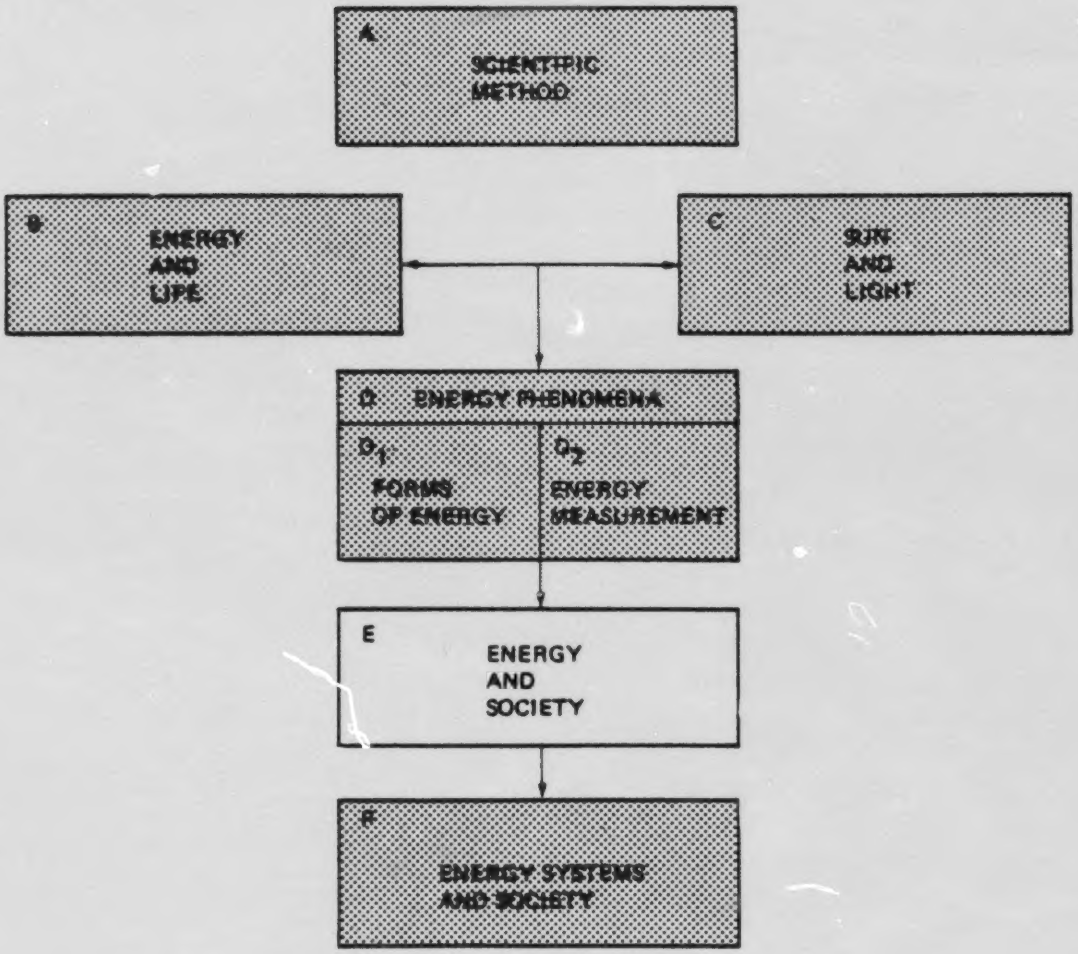
SPECIAL NOTES

As variation to the classroom experiment, the procedure can be repeated with the silicon cell not on the horizontal surface, but tilted on some sort of little rack. The rack can be aimed in different directions, i.e., due South, East, West, and even North. The students can then see for themselves what effect placement of solar collectors have on the actual amount of solar energy that can be collected over the day.

DETAILED ENERGY MEASUREMENTS

Unit $D_{2\text{-}VI}$ (Approximate Grade Level #6)

It is suggested that lessons B_{VI} and I_{VI} be used to demonstrate the measurement of energy requirements (C.F. B_{VI} page B-32 and F_{VI} page F-30).


A
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ENERGY SYSTEMS
AND SOCIETY

ENERGY AND SOCIETY AWARENESS

We, in the United States, consume a huge chunk of the energy used in the world today, while we are a small part of the world's population. Most of the energy we use comes from such resources as petroleum, natural gas, coal and wood. All but wood are non-renewable energy sources, that is, once they have been burned, they cannot be replaced. Wood can be replaced, but it takes years to grow new trees to replace ones cut down. Our present supply of non-renewable energy sources is running short. What can we do to keep from running out of energy?

One thing we can do, is to look for other energy sources. Can you name some? Some of the other energy sources that exist include nuclear, hydroelectric (dams), geothermal, tidal, and solar. There are many problems and limitations to these energy types. Nuclear energy is costly requiring sophisticated techniques in its application, along with problems concerned with waste disposal. Permanent containment of nuclear waste (fission products) is a major issue. Hydroelectric, or energy that comes from dams, has already been fully utilized in the United States and a few other potential hydroelectric energy sources exist. Geothermal energy in the form of steam or hot water that comes from the earth, may be harmful to the environment since it can contain unwanted chemicals. These chemicals may also be harmful or corrosive to parts of the geothermal energy plant, problems with tidal energy exist because of the large high and low tide differences that are needed (tides are different in coastal water levels during the day). Only a few spots on the earth have large tide differences. Solar energy is one form of energy that is continuously available and is a renewable source of energy. It is also a clean source of energy, there are no waste products or harmful chemicals and it can be used from heating hot water to producing electricity. One problem that exists with solar energy, as well as other energy forms, is the cost of converting it to usable form. Presently, (1978) it costs less to produce electricity from fossil fuels than from other energy forms.

Another thing we can do to keep from running short of energy, is to conserve energy. Conserving energy means to use less and waste less energy. In this way we can stretch the lifetime of our present non-renewable energy sources. There are many ways of conserving energy in our homes. Can you name a few? Some ways to save energy in the home are given below:

1. Only use lights when they are necessary, unless of course, if you're the kind that sees in the dark, you won't be needing any light.

2. Only use hot water when necessary and lower the temperature control on your water heater. Lowering the temperature on water heaters saves energy.

3. While heating or cooling, keep all outside windows and doors closed. This keeps energy from getting away from us.

4. Use dishwaher, dryer, and washing machines only with full loads. It saves energy to wash one full load instead of two half loads.

5. Lowering the thermostat temperature in winter also saves energy. How is this done? Since outside weather is cold during winter, we want to keep the inside conditions at a higher

temperature (usually called room temperature). The warmer we want the inside to be, more heat must be added and more energy is used. We also use energy to run air conditioners in the summer to keep the inside cooler than outside. By using the air conditioner less, we may get a little warmer, but we can save a lot of energy.

These are only a few of the many ways to save energy.

HISTORY OF SOLAR ENERGY

In prehistoric times, it may have been obvious to human beings that the sun was essential to life on earth, giving off solar light and heat. Many of the early cultures that developed identified the sun as a God, the creator of life on earth. The Aztecs, Incas, Babylonians, and Egyptians were sun god worshippers.

Direct, natural use of the sun has been practiced since the beginning of agriculture not only for growing plants but also for drying fruits, vegetables, and other crops. Early civilization explored other ways of utilizing solar energy. The Egyptians found ways to store solar heat through transparent surfaces. The Arabs used solar energy to distill brackish water. The Aztecs used solar energy to dry clay pottery and vessels.

An unusual use of solar energy was made by Archimedes in a military confrontation between Greek soldiers and an invading Roman fleet in the harbor of Syracuse, Greece in 212 B.C.. The story is told that the Greek soldiers lined up along the harbor and used their shields to reflect sunlight on the invading Roman fleet. The high concentration of sunlight focused on the warships was enough to set fire to them.

With the advent of glass occurring around the first centruy A.D., public bath houses and expensive homes built by Roman craftsmen were kept warm using glass windows for trapping solar heat.

Little scientific progress occurred in solar energy after the advent of glass until the Renaissance. Some advancement had been made in the science of observing, optics, by Roger Bacon through the use of lenses and spherical crystals.

Interest in solar energy increased during the Renaissance era as scientists used solar devices in their experiments to burn substances, raise water, and to heat or melt metals. Eighteen hundred years after the story of Archimedes, in the seventeenth century, Athanasius Kircher performed some experiments to set fire to a woodpile at a distance in order to determine the validity of the story of Archimedes.

Further investigation led by George Buffon demonstrated in 1747, that a woodpile 60 meters (197ft) away can be ignited using a number of small flat mirrors. Count Buffon concluded that Archimedes' feat in burning the Roman warships was possible.

Antoine Lavoisier, the founder of modern chemistry, discovered oxygen as the gas produced by intense heat concentrated onto mercuric oxide by a system of lenses directed toward the sun (1774). Temperatures up to 1760°C (3200°F) were produced by the lens system.

In 1839, an attempt to generate an electric current by action of sunlight was successfully accomplished by A.E. Bequerel. In the latter half of the century, attempts were made to convert solar energy into other energy forms such as generating steam to operate steam engines. A notable advance was made in the latter half of the 1800's by a French man named August Mouchot. He designed a cone shaped collector called an axicon. Unlike lenses and other reflecting devices which focused over a small area producing extremely high temperatures, the Axicon focused sunlight over a wide area producing moderate temperatures. Abel Pifre, a contemporary of Mouchot, developed parabolic reflectors similar in shape to Mouchot's cone. Pifre's solar engine demonstrated at the Paris Exhibition in 1878, was used to drive a printing press.

In 1872, large scale utilization of solar energy was developed in Chile by Wilson. A solar still was built to provide much needed fresh water from salt water. This still operated for 40 years and supplied up to 6,000 gallons of fresh water per day.

Significant developments were occurring at the dawn of the 20th century. New ideas began to crop up as combined solar steam powered devices and storage batteries were developed as possible power systems. Experimenters were using more sophisticated engines to improve efficiencies. A different approach to solar engines was developed by Willsie and Boyle from 1902 to 1908. They used what is now known as flat plate collectors to absorb sunlight. These units became well developed for domestic hot water heating in the Southwestern United States and Florida. But with the discovery of cheap oil and natural gas that occurred, solar hot water systems became much less competitive than gas fired water heaters.

In 1912, Frank Shuman and others, developed the world's largest solar pumping plant in Egypt. The steam supplied to the steam engine used to drive the water pump was produced by parabolic cylinders reflecting light onto an absorber tube. Each cylinder was 62 meters long with a total area of 1200 square meters.

Development of solar energy for practical purposes has long been delayed due to cheap fossil fuel costs. But in the area of hot water heating, there is more success. Many solar hot water systems in the United States and elsewhere remain in use.

Developments made by Bell Telephones' scientists in the 1950's, greatly improved solar energy conversion into electricity: first made by Berquerel in 1839. The new photovoltaic cell later became useful in providing power for spacecraft. This new energy source was promising to space exploration as a cheap power supply, but compared to providing domestic power on earth, conventional electricity generating systems such as steam turbine power plants costs far less.

ENERGY AND THE WAY WE LIVE OUR LIVES

Unit E_K (Approximate Grade Level K)

OVERVIEW

This lesson will tend to introduce to the students the connection between the use of energy and the way they live. The students will be directed in play to pretend they are in the "old times" and therefore must live with energy form of that time.

LEARNING OBJECTIVES

Students will be introduced to the concept of energy involved with their life styles by directed play. The play will be pretending they are in the "old times".

EVALUATION

Observe the attention of the students.

SPECIAL MATERIALS

There are no special materials required for this lesson. Items may be improvised to fit in with the play.

VOCABULARY

Energy, gas, electricity, solar

LESSON PLAN

(The following is one method of directing the play of the students. Any directed play that will make the students aware of the use of energy in their life will also be acceptable.)

- Have the students pretend they are living in the old times when people crossed the country in covered wagons. They are out in the open country and it is becoming nighttime. It is getting cold.
- Ask the students, how we can make ourselves warm.
- Ask if we can turn the thermostat up like we do at home. Contrast the way we keep ourselves warm now, with having to go out and find firewood.
- Have the children pretend they are gathering wood and have them make a "bon fire" in the middle of the room.
- Have the students sit on the floor around the camp fire.
- Ask them if they are getting hungry.
- Talk about how one can cook his food over the open fire.
- Contrast that with how we can use a stove today.
- Introduce the terms of gas and electric indicating how we can cook our food now.
- Talk about using the sun to cook food and to dry food.
- Play may be directed as long as one has the attention of the students bringing up other problems such as having lights to see by, television and radio sets to watch and listen, and other parts of their normal lives that did not exist then.

- The lesson can conclude by using a solar hot dog cooker to show how we can still use the sun to do some things like cook our food.

SPECIAL NOTES

This particular lesson leaves much room for teachers and their ingenuity if they desire. Concepts such as the one described above could simply be used once the students are all sitting around "campfire" to tell a story or read a story in relation to the use of energy. Other settings of time could be used i.e., cavemen, living on a tropical island, being on a boat, and so forth.

E_I

ENERGY AND THE WAY WE LIVE OUR LIVES

Unit E_I (Approximate Grade Level #I)

OVERVIEW

Through a combination of small projects, self expression and demonstrations, the students will further learn the interaction between the use of energy and how it effects their lives. Using a simple demonstration, they will also be introduced to the concept of energies that can only be used once — (non-renewable) and energies that may be used over and over — (renewable energies).

LEARNING OBJECTIVES

Students will increase their realization of the ties between the use of energy and the way we live our lives. They will also be introduced to the concept of renewable energy and non-renewable energy.

EVALUATION

After the lesson, show the students pictures of different forms of energy. Have the students identify which are renewable and non-renewable energy forms. The class should be able to identify the energy forms correctly.

SPECIAL MATERIALS

- For each student, a small piece of heavy construction paper or light cardboard approximately four inches by five inches.
- For each student, a brass spreading brad.
- Crayons and paper
- Magnifying glass

VOCABULARY

Energy, electricity, conserve, renewable

MOTIVATION

See if the students know what the term energy means and what energy is used for.

LESSON PLAN

(The following activities represent three separate parts of the lesson. The first part of the lesson will deal with the use of energy in our present lives.)

- Students will be asked to look over magazines and find pictures of people or things that use energy. This can be done in class, at home, or via directed study by showing the pictures.
- The students will talk about the pictures, what people are doing.
- The students will post the pictures on a board or separate bulletin board called, "The energy bulletin board".

  (The second phase of this lesson involves making the students becoming aware of the concept of conservation of energy. They will make small switches that will be used to "turn their desk locations on or off.)

- Take the four by five inch piece of cardboard.

- Have the students cut a strip of cardboard approximately one inch long from the long length (i.e., if the cardboard were originally 4 x 5 inches, this cardboard will now be 4 x 4 inches).

- Have the students put the remaining larger piece of cardboard in front of them on the desk. In the upper right hand corner, have the students print the word "on". In the lower right hand corner, have the students print the word "off".

- Put a small hole in the one inch by four inch strip of card about one inch in from the end.

- Have the students make a hole in the larger piece of cardboard about one inch in on the end opposite from where they have printed the words "on" and "off" and about along the mid-line of the card.

- Have the students put the brass brad through the hole on both the larger piece of cardboard and the smaller piece and then spread the brad.

- By moving the longer thin piece of cardboard up to cover the word "on", the students will have turned their desks "off". When they slide the piece of cardboard over the word "off", they can turn their desks on. (If you wish, the reverse can be true.)

- When the students get up and leave their desks, they should turn their desks "off". If a student left his desk and did not turn it "off", he should be told that he has not done that, and to go back and turn his desk "off". If while sitting at his desk, it has not been turned on, the teacher should tell him so, and he will not be recognized with his raised hand until his desk is "on".

- If a student does not want to be disturbed by others, he can sit at his desk and turn it "off".

(The last phase of the lesson will demonstrate to the students the concept of renewable and non-renewable resources.)

- Take the students outside. Using a match, light the match and in turn, light the end of a piece of paper. Quickly blow the paper and match out.

- Ask the students how we can light the paper again. Can we use the same match again?

- Use this to introduce the concept of an energy form we can only use once, a non-renewable form. The match is a good example. Other examples are gasoline that can

- Take the magnifying glass and light the paper by concentrating the sunlight on to it.

- Quickly blow the paper out. Ask the students again how we can relight the paper. Can we do it using the same magnifying glass? This will demonstrate to them the concept of a renewable resource such as the sun that does not get used up each time we make use of it.

SPECIAL NOTES

This lesson can be liberally modified by the teacher if so desired. The phases of the lesson can be done at different times or combined in one session. The concept of the on-off desk switch could be used over a longer term or for a short period of time depending on the particular class.

ENERGY AND THE WAY WE LIVE OUR LIVES

Unit E_{II} (Approximate Grade Level #2)

OVERVIEW

Working with smaller groups or full classes, the students will "brainstorm" different ways of accomplishing various tasks that may require energy. After a particular list is compiled, the teacher introduces other constraints such, as in the case of transportation, no gasoline. Then see which one of the items on the list will not be able to be used. A discussion will be led on the concept of which resources are reusable or renewable, and how the use of energy may affect the environment. The students will be encouraged to think of energy conservation measures that may be used in their classroom or school environment.

LEARNING OBJECTIVES

Students examine the connection between the way we use energy and how we live our lives. They increase their knowledge of the concept of reusable and renewable resources and the effect on the environment. The conservation ethic is emphasized.

EVALUATION

The students should be able to identify renewable and reusable resources as contrasted to non-renewable or non-reusable resources. The students should achieve some realization of the connection between uses of energy and the way we live our lives.

SPECIAL MATERIALS

Special worksheet dealing with renewable/non-renewable resources and environmental effects.

VOCABULARY

Energy, reusable, renewable, environment, pollution

MOTIVATION

The students may have a pre-lesson motivation on their knowledge of which energy sources are reusable or in renewable, using the special provided worksheet.

LESSON PLAN

- Using small groups (preferable) or the class as a whole, pose to the students various tasks, and ask them how we may accomplish these endeavors. Example:

  - going to the store from school*
  - keeping the house lit at night
  - keeping the house warm
  - keeping the house cool

  Other tasks may be suggested by the teacher or the students themselves.

- Then start eliminating mentally the use of various sources; e.g., tell the students there is no gasoline today, how would you go to the store. Tell them how they cannot use the car or the bus. Carry this through a series of steps; i.e., after the gas elimination, no energy to make tires, eliminating the use of bicycles.

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*Have the students say the various ways that these jobs can be accomplished. e.g., to go to the store, we may drive a car, take a bus, ride a bicycle, etc.

(The following activities may be carried out at the same time or as a separate exercise later.)

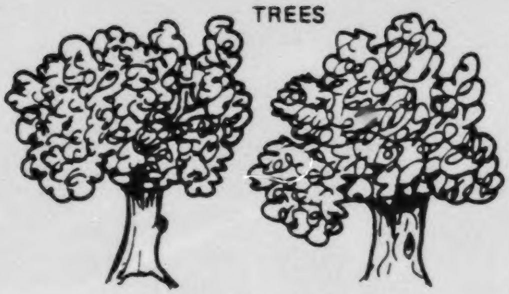
- Have a class discussion about resources that can be used only once while others can either be used again or made again. For instance, we can only burn gasoline and coal once; we can reuse solar energy each day. We can burn down a tree and only use it once; but we replant a forest and renew the resource of wood for later periods of time.
- Have the students use provided worksheets (Figure E-1) to point the discussions to various energy sources and whether they can be used again and again, or can only be used a single time.
- During this discussion, ask what happens to the environment when we use the resource. Do we cause pollution to the air in places we live? For example, burning wood may cause smoke and ashes, but will that hurt us? Burning gasoline may cause smog. Using the sun's energy does not cause pollution, but to manufacture the materials in a solar oven or solar instrument may cause us to burn oil or other things that actually do cause pollution.
- Have the students take out a clean piece of paper and list or draw pictures of ways to conserve energy. These might be using a bicycle instead of riding a car, turning off the

lights when you are not using them, watching a smaller TV set rather than a larger one, using solar energy and so forth.

SPECIAL NOTES

The main emphasis of this lesson is to firm in the students' minds interactions of the use of energy and our lives. This may be something very direct such as eliminating the things we can do or can be something indirect such as pollution that may in turn affect animal or vegetable life around us, let alone burn our eyes. Discussions may be used when the students can talk about things at home that use energy, how they use energy at home; i.e., if they turn the lights off when they leave the room and items of that nature. Special projects could be assigned such as having students count the number of light bulbs on each night and the number of rooms that they have with lights on. Discussions can then be held on whether they needed all those lights and whether there were people in all those rooms. Discussions can be held about how they go from place to place if they ever walk or if their mothers and fathers always drive. Children can be encouraged to draw pictures or write short essays about what life would be like without certain kinds of energy, such as gasoline, electricity, and natural gas.

WORKSHEET – LOOKING AT ENERGY

	CLEAN	RENEWABLE	LOW COST
TREES 			
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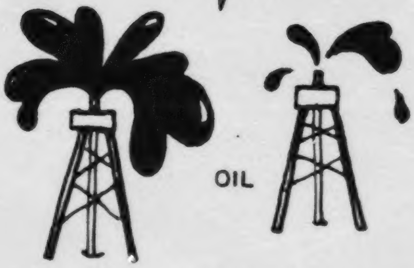
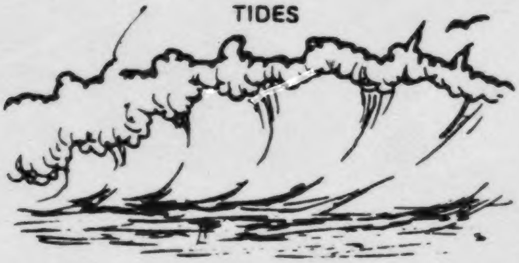
 OIL			
TIDES 			
WIND			

Figure E-1. Looking at Energy Work Sheet

THE USE OF ENERGY AND THE WAY WE LIVE OUR LIVES

Unit E_{III} (Approximate Grade Level #3)

OVERVIEW

Students are first introduced to various new kinds of alternative energy sources. Then working in small groups of 4 to 6 students, the students design ways of accomplishing tasks utilizing these alternative energy sources. A neighborhood class walk is carried out where the students take time to note all the various ways that energy may be used around them.

LEARNING OBJECTIVES

Students grow in their recognition of the interconnection between the use of energy and the types of lives they live. Students are made more aware of other alternative energy sources. A neighborhood walk is used to carry out a loose energy use survey of the local area.

EVALUATION

Students should be able to identify alternative energy forms. Class participation in identifying use in the neighborhood should be enthusiastic.

SPECIAL MATERIALS

- Special film strip describing alternative energy sources.
- Special alternative energy worksheet.

VOCABULARY

Solar energy, wind energy, geothermal energy, biomass energy

MOTIVATION

Using the special worksheet, students are initially evaluated on their ability to recognize alternative energy sources and the characteristics of those sources in relation to effects upon the environment.

LESSON PLAN

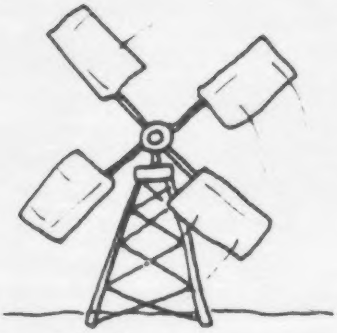
- Using the special film strip (Alternate Energy), the students are introduced to various forms of alternative energy and some effects they may have on the environment.
- After the film strip presentation, divide the students into groups of four to six. Pose a particular problem to each group such as a method of warming houses, a method of making vehicles move, a way of making electricity or a design of a classroom.
- Have each group decide how they might be able to use some of the alternative sources to do the things they wish. They can draw pictures and/or they can list the ways to do the jobs.
- After the groups have finished their tasks, reassemble the class and have a general sharing period where the students interchange their ideas and discuss the designs.
- Using the special worksheet, have the students identify various alternative energy forms.
- At this time or a later period, take the class on a walk around the neighborhood making a list of all possible kinds of

energy they might see used. e.g., gasoline in cars, electricity in lines, chimneys where we burn wood, children riding bicycles and so forth.

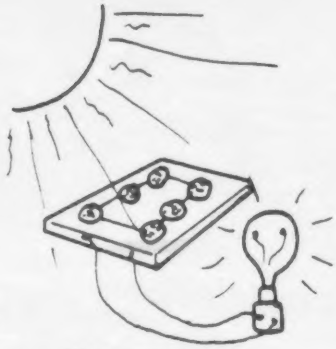
- Students may return to the classroom and discuss the energy they have seen, the ways it is used and the possible ways energy may be conserved.

SPECIAL NOTES

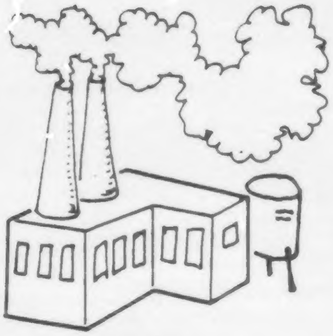
Again this type of lesson is mainly used as a thought provoker. The teacher is encouraged to use originality and modification if so desired. This type of lesson can be fitted very well into a general social studies or other humanities type program.



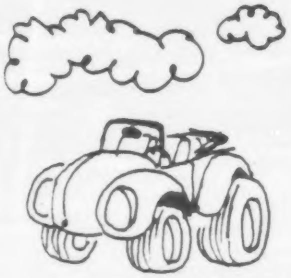
___ WIND
___ SOLAR
___ NUCLEAR
___ GEOTHERMAL



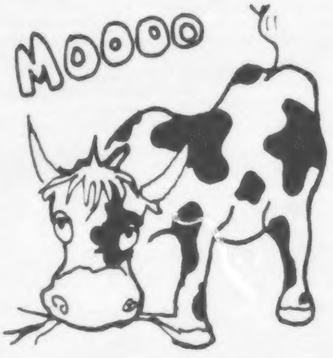
___ SOLAR THERMAL
___ PHOTOVOLTAIC
___ BIOMASS CONV



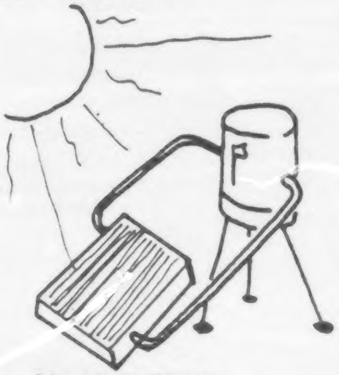
___ FOSSIL FUEL
___ GEOTHERMAL
___ MECHANICAL
___ NUCLEAR



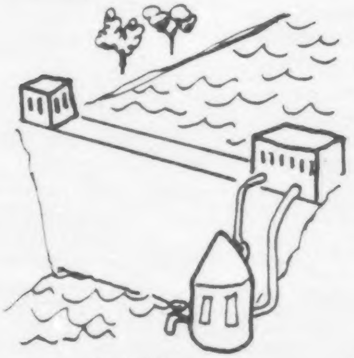
___ FOSSIL FUEL
___ SOLAR THERMAL
___ MECHANICAL
___ CHEMICAL



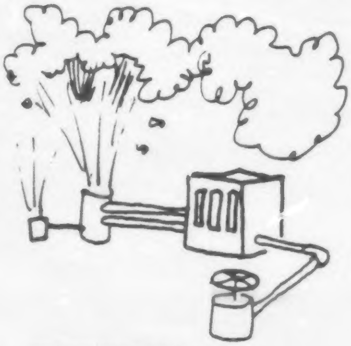
___ SOLAR THERMAL
___ BIOMASS COV CONV
___ MECHANICAL
___ CHEMICAL



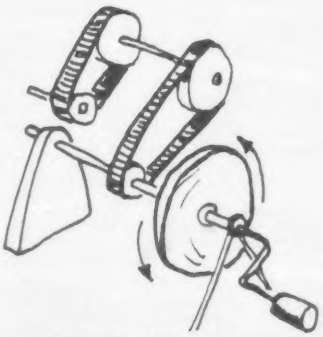
___ SOLAR THERMAL
___ PHOTOVOLTAIC
___ WIND
___ BIOMASS



___ NUCLEAR
___ HYDRO
___ SOLAR
___ WIND



___ GEOTHERMAL
___ HYDRO
___ NUCLEAR
___ SOLAR THERMAL



___ GEOTHERMAL
___ MECHANICAL
___ WIND
___ CHEMICAL

Figure E-2. Alternate Energy - Sample Work Sheet

ENERGY USING DEVICES THAT ARE IMPORTANT IN OUR LIVES

Unit E_{IV} (Approximate Grade Level #4)

OVERVIEW

After a class discussion about energy using devices, the students will take time to write a short essay on things that use energy that are very important in their lives. After the essays are written, each student, in turn, will read his written material. The teacher at his discretion, may have a brief class discussion following each essay. The class will very quickly see how energy is important in the way they live their lives.

LEARNING OBJECTIVES

The students will, through self examination, determine items that use energy that are important in their individual lives.

EVALUATION

The students will participate and write a one paragraph essay about things that use energy that are important to them.

SPECIAL MATERIALS

No special materials are needed for his lesson.

VOCABULARY

Energy, Electricity, Gas, Life Style

LESSON PLAN

The teacher will ask the students to look around the classroom and identify items that use energy. The students will be encouraged to find a variety of items that use more than one energy source, e.g., such as radios using electricity, heaters or stoves using natural gas, items that might use bottle gas, etc. Once the classroom discussion has concluded, the teacher will ask the students to stop and think a moment about things at home that use energy that they consider very important in the way they live their lives. The teacher will then ask each student to write a short essay about those things.

ACTIVITIES

1. Following the lead in motivation, the students will be given approximately 15 to 30 minutes, depending upon the individual class, to write their essays.

2. Each student will be allowed to stand up and read the essay.

3. The teacher may, if so desired, conduct a brief discussion following each essay about the items mentioned.

4. The teacher should be making note of a particular item that the students name off. By and large, about 75% of the students usually write about the requirements of a TV set.

5. Following the reading of the essays, the teacher can talk to the students about the various things they thought were important in their lives. A discussion can follow that will direct the students' attention to the concepts of life style and what an important role the use of energy plays in the kinds of lives the students want to live.

SPECIAL NOTES

This lesson can be very easily bridge to studies dealings in the social sciences. Students can carry out projects such as collecting information about things that use energy that appear in the newspapers, or any other lesson that the teacher may determine connects with the use of energy.

E_{IV}

SOLAR ENERGY SYSTEMS

Unit E_{IV} (Approximate Grade Level #4)

OVERVIEW

(It is suggested that the teacher read the supplied background information on solar energy systems before conducting this lesson.) The students are introduced to the concept of a basic solar energy system composed of four major components (a solar energy collector, a method of storing the collected energy in some form to be used later, a method of transporting the stored or directly collected energy to where it is needed, and some method of controlling the overall system operation). The students will perform simple experiments, some of which may have been done in previous lessons but this time the students analyze the various functions that are going on. The simple experiments are: 1) painting jars with certain colors and examining the final result as a "solar energy system", and 2) optional experiments utilizing the solar hot dog cooker and/or the sun store battery charger.

LEARNING OBJECTIVES

The students are introduced to the concept of a solar energy system, and experiment with various simple devices to better understand the individual role of each "component" in the overall "system".

EVALUATION

Students will achieve a basic understanding of a "solar energy system" and the various major components comprising it. This evaluation can be achieved by having the students draw a picture of a solar system pointing out the individual components.

SPECIAL MATERIALS

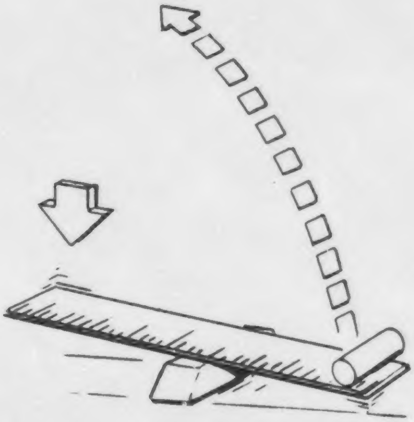
- Two or three empty jars (large size mayonnaise jars will be ideal)
- Necessary materials for each student or teams of students to individually construct "10c hot dog cookers". (Optional)
- Sun store solar battery charger (optional).

VOCABULARY

Collector, Storage, Transport, Control, System

MOTIVATION

Pose the question to the students "What is a system?" (A system is a series of components or pieces put together in such a way that they all accomplish a certain task in the most efficient manner.) The teacher can illustrate a concept of a "system" using a very simple device can be a small catapult constructed by laying a ruler on top of an eraser. A small piece of chalk can be put on the downside of the ruler and when the high side is struck, the chalk will fly across the room. The teacher can say the job that wishes to be done is to shoot the chalk as far as one can. To accomplish this task, the catapult is our "system". The various components of the system are the chalk, the ruler, the eraser, and the person who hits the ruler to fire the chalk. A study can be



made to determine which side the eraser does the best job, where the eraser should be placed along the ruler, and how hard one should hit the ruler (so that the chalk does not go straight up in the air or hit the ceiling). This will be a "system study". The students will now be asked to do a system study in solar energy.

LESSON PLAN

- Carry out the motivation. Stress to the students the individual role of each component in the catapult. Encourage a discussion on how big or which eraser should be used, how hard one should hit the ruler, etc.

- Carry out a blackboard study of a solar energy system in the following manner:

  Ask the students what will be needed to make a system that will collect sunlight, keep its energy and let us use it later on? The discussion will have to be led, no doubt by the teacher. Have the teacher lead the discussion so that the students will see that the things needed are: 1) a collection component to catch the sun's energy and convert it into some other form that we can store (e.g., heat into water, electricity, etc.). A second component will be some way of storing that energy (a hot water tank, batteries, etc.). The third component will be come "transport subsystem" that will allow us to take the energy we have stored and put that energy where we will need it (e.g., pipes for my hot water tank to our shower, wires from a battery to a light, etc.). The last and fourth major component will be some form of "control". That is a method of making sure this system works properly (e.g., turning on a pump to circulate water from a tank to the solar collector, turning on a switch to allow current to flow from the battery to the light, etc.).

- The teacher will show the students the glass jars and ask, "Can we make these glass jars into solar energy systems?"

- If the students paint the outside of one of the jars black so that will absorb the sunlight and convert it into heat energy, they will make a "solar collector". If then they fill the jar with water and screw the cap back on the jar, that will also be a solar energy storage system, i.e., the outside paint and glass will be the solar collector, it will get hot and the solar energy will be transferred as heat into the water and stored inside the jar. Later the students, using care not to burn their hands, can pick up the jar, bring it in after it has been in the sun and warmed and use the hot water where they need it, i.e., they will become the transport component. Question: What about the control component? If the students paint half the bottle black and half the bottle white, then only part of the jar will be a solar collector and the final temperature of the inside water after a specific period of time will not be as hot (this form of control painting is one way spacecraft have their inside temperatures controlled).

- Have the students paint one jar completely black. Have them paint another jar completely white. A third jar should then be painted in some pattern so that approximately half the jar is white and half the jar is black.

- After the paint has dried, carefully fill the jars with water and replace the caps.

- Place the jars in bright sunlight for approximately 30 minutes (the specific time placed in the sun can be determined to obtain a maximum effect of the experiment). After the specific time has elapsed, have the students go outside and measure the temperature of the water using a thermometer. What are the temperatures? Are they different? Has our painting the jar white or partially white controlled the temperature of the inside water?

- The experiment can be repeated using different forms of patterns on the jar and letting the jars sit in the sun for different periods of time.

- The students can each make, as an optional exercise, a 10¢ solar hot dog cooker. Have the students analyze how the hot-dog cooker works in relation to a solar energy system. The sunlight is collected over an aluminum foil surface. It is then reflected onto the hot dog itself. The hot dog then absorbs the solar energy and stores it inside the skin of the hotdog. As more energy is stored, the temperature of the hot dog increases and eventually cooks. There are actually two forms of transport of energy here. The light energy is reflected onto the hot dog and is transported from the aluminum surface to the hot dog by optical methods. Once the hot dog cooks, it is transported to the sun by mechanical methods (the students' hands). The control is accomplished by how well we aim the hot dog cooker to the sun and how long we allow it to sit and collect the solar energy.

- Another optional adjunct to the lesson can be the demonstration of the sun store battery charger. The photovoltaic solar cells act as a solar energy collector. They convert the solar light energy directly into electricity and then the electricity is transported along the wires to the battery. The electrical energy is then stored inside the batteries in the form of chemical energy. We can then later transport that energy, i.e., take the batteries and carry them to where we need them to run such devices as toys or flashlights.

SPECIAL NOTES

This lesson in general is considered very beneficial from the standpoint of teaching the students the art of observation and logical thoughts about things in our everyday lives. We can look at many tasks or jobs we do using a "system approach". This is simply a matter of analyzing how we do things step by step, to achieve a method of accomplishing a task in a most efficient manner. Even the simple task of writing on paper can be thought up as a systems approach, e.g., the most effective way of holding the pencil, the best angle that the paper should be turned on the table, the proper pressure applied during writing, and any other specific component that may be of prime importance. As follow-up activities, the students can pick a system of their own choosing and write a small essay listing the various components of the system and what these various tasks are that the components accomplish.

ELECTRICITY AND ENERGY CONSERVATION

Unit E_V (Approximate Grade Level #5)

OVERVIEW

Students will carry out measurements of electric utility meters at home and possibly also at the school premises. The students will log the amount of electrical energy utilized over a period of time and try to correlate the energy used with the specific energy drawing appliances or machinery. The students can discuss the results and through the discussion, come up with suggested ways of conserving energy to minimize electrical energy use. Any students that wish to carry out an energy conservation program correlating the actual savings with continual electrical utility meter readings over the school semester should be encouraged to do so.

LEARNING OBJECTIVES

The students will learn concepts of energy conservation. They will be shown how to read electricity meters and then conduct surveys of electrical energy use. Based on the findings of the students, they will suggest methods of conserving electrical energy.

EVALUATION

Students will successfully be able to read the electric meters.

SPECIAL MATERIALS

Special electric meter worksheets.

VOCABULARY

Conservation, Kilowatt-hour

LESSON PLAN

A teacher can ask the students if they like to save money? After they all say "yes", the teacher can point out that one way to save money is to conserve energy because energy is very expensive today. The teacher can ask the students if any of them would like to learn how to save electrical energy. The lesson will be to learn how to read the electric meter and how to save electricity.

It is suggested that the teacher first read the background material budgeting electricity to familiarize themselves with the method of reading meters, the method of calculating kilowatt-hours, to learn approximate energy requirements of major appliances, and obtain suggestions for conserving electrical energy.

- The teacher will show the students how to read an electric meter (C.F. pages E-38 through E-43).

  The teacher can also supply to the students a list of electrical energy appliances.

  The teacher can then make a meaningful math exercise by supplying to the students certain electrical appliances. It then can be suggested as to what period each day these appliances will be run, e.g., two 75-watt electrical light bulbs for four hours each day. The students can then calculate the amount of kilowatt-hours used per month (assuming a 30-day month) that the particular appliance or electrical energy consumer will require.

- The students can then make a list of items in the school that use electrical energy and/or items in their homes that use electrical energy. Have the students refer to the list of major electrical appliances and electrical houseware and small appliances that are supplied with the background information for the teacher.
- Have the students estimate how much electrical energy they think the school and/or their home may consume each month.
- Have the students then carry out electrical energy measurements by reading their electricity meter.
- The students can take their monthly estimates and make average daily energy use estimates.
- Have the students compare their daily meter readings with their original estimates.
- Class discussions can then be held on ways of conserving electrical energy (e.g. turning off lights at home in rooms that are not in use) utilizing energy conserving techniques with refrigerators, etc.

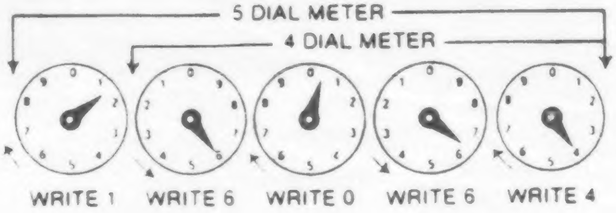
SPECIAL NOTES

The teacher at this point may wish to reshow the film strip on energy conservation that is used in the earlier grade levels. This film strip will illustrate methods of producing electrical energy, as well as other energy forms, and discuss the general concept of energy conservation. The students can also prepare short essays on methods of conserving electrical energy.

HOW TO READ YOUR ELECTRIC METER

NAME ____________________

The dials are like watch faces lined in a row (every other dial moves counterclockwise). The reading for a five dial meter would be 16,064. The reading for a four dial meter would be 6,064.

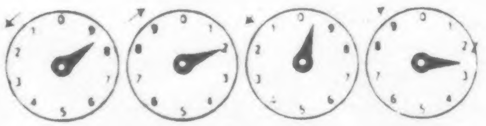


Notice that when the pointer is between two numbers, you should record the lower of the two numbers.

When the pointer seems to be directly on a number, look at the dial to the right; if the pointer on the right side dial has passed "0" then write down the number the pointer seems to be on; if the pointer on the right side dial has not passed "0", then write down the previous lower number on the dial you are recording.

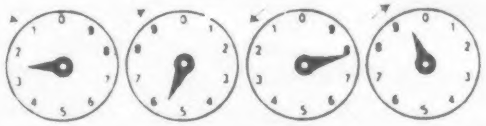
RECORD THE READINGS FOR THE FOLLOWING METERS

METER NO. 1

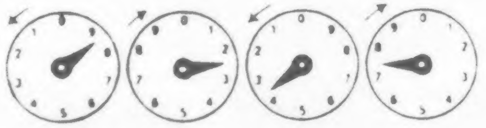


A 8 1 9 2

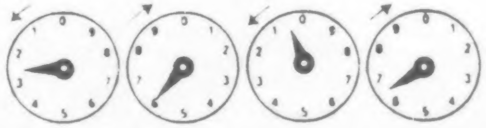
METER NO. 2



A 2 5 7 9



B 8 2 3 7



B 2 6 0 6

Subtract the number on line A from the number on line B to find the number of KWH of electricity used.

METER NO. 1

Line B 8237

Line A 8192

KWH used 45

METER NO. 2

Line B 2606

Line A 2579

KWH used 27

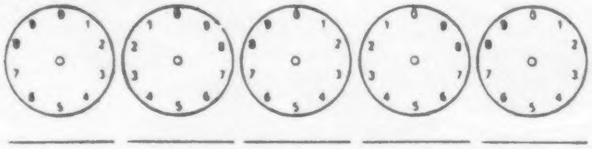
METER READING RECORD

NAME ______________________

TO TELL YOU IF YOU ARE CONSERVING ELECTRICITY, READ YOUR ELECTRIC METER.

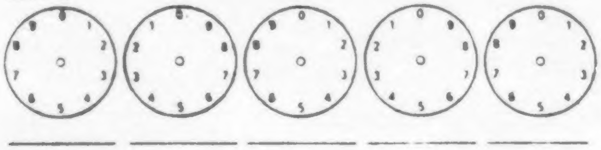
1. Draw the positions of the hands of the meter on the dials below.
2. Write the number in the space below each dial. Do this every day for seven days at the same time each day.

DAY 1



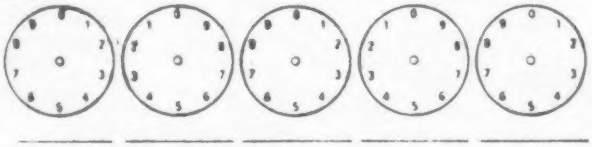
Meter Reading Day 1 ______________

DAY 2



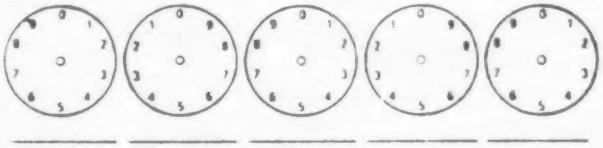
Reading Day 2 ______________
Reading Day 1 ______________
KWH used ______________

DAY 3



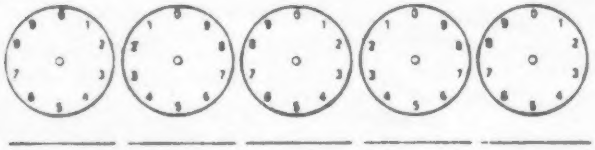
Reading Day 3 ______________
Reading Day 2 ______________
KWH used ______________

DAY 4



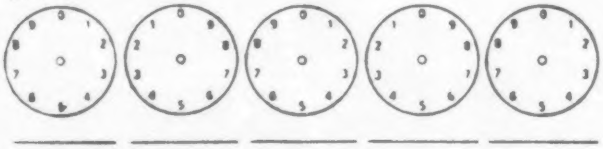
Reading Day 4 ______________
Reading Day 3 ______________
KWH used ______________

DAY 5



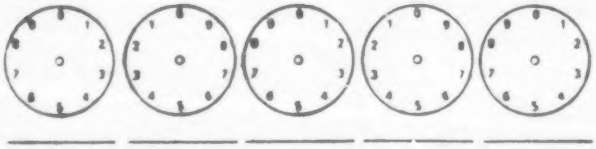
Reading Day 5 ______________
Reading Day 4 ______________
KWH used ______________

DAY 6



Reading Day 6 ______________
Reading Day 5 ______________
KWH used ______________

DAY 7



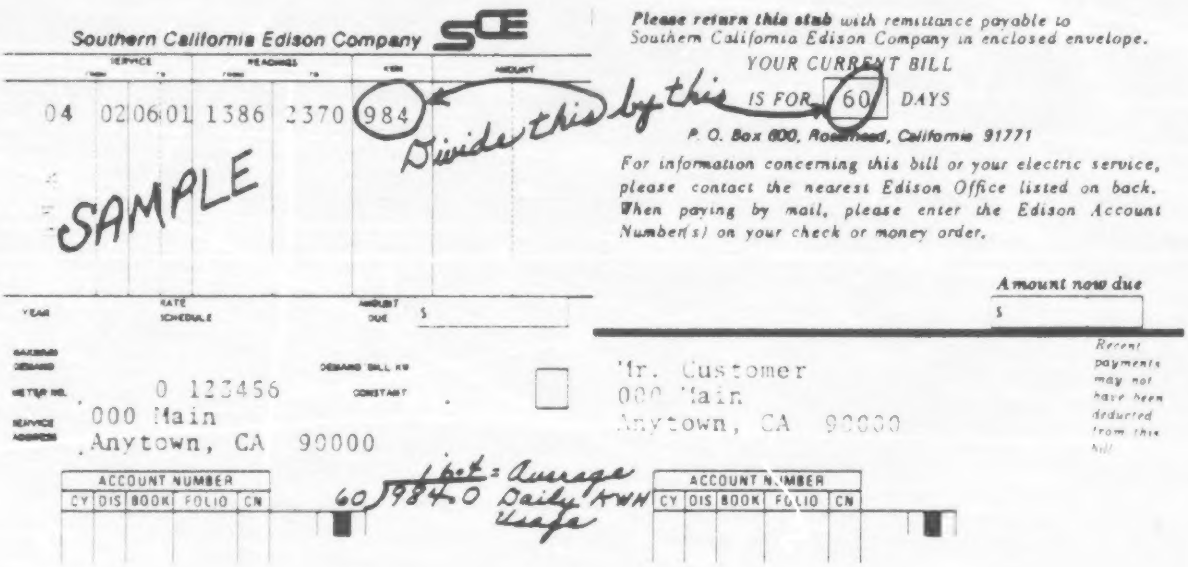
Reading Day 7 ______________
Reading Day 6 ______________
KWH used ______________

BUDGETING ELECTRICITY

It is important to plan and budget your use of electricity just as you plan for expenses such as transportation, food, housing and clothing. An electrical budget can help keep your bills down and at the same time help ease demands on the nation's fuel supply.

This pamphlet is designed to help you save money and conserve energy in your home. Included are some conservation of energy tips and a chart of typical electric usage of common household appliances. Also, to help you have a better understanding about the electricity you use, we have furnished information about your electric bill and instructions for reading your meter.

How To Read Your Bill



Southern California Edison Company SCE

SERVICE READINGS KWH AMOUNT

04 02 06 01 1386 2370 984

SAMPLE

Divide this by this

YEAR RATE SCHEDULE AMOUNT DUE $

DEMAND BILL KW

METER NO. 0 123456 CONSTANT

SERVICE ADDRESS
000 Main
Anytown, CA 90000

ACCOUNT NUMBER

CY	DIS	BOOK	FOLIO	CN

$60\overline{)984.0}$ 16.4 = Average Daily KWH Usage

Please return this stub with remittance payable to Southern California Edison Company in enclosed envelope.

YOUR CURRENT BILL IS FOR 60 DAYS

P. O. Box 800, Rosemead, California 91771

For information concerning this bill or your electric service, please contact the nearest Edison Office listed on back. When paying by mail, please enter the Edison Account Number(s) on your check or money order.

Amount now due
$

Mr. Customer
000 Main
Anytown, CA 90000

Recent payments may not have been deducted from this bill.

ACCOUNT NUMBER

CY	DIS	BOOK	FOLIO	CN

Here's how to figure your daily usage of electricity from your electric bill.

The amount of electricity you use is measured in kilowatt-hours. It is shown that way on your bill under the heading "KWH". One kilowatt-hour is 1,000 watts of electricity used for one hour, or 100 watts — such as a 100-watt bulb — used for 10 hours.

The sample bill above shows a usage of 984 kilowatt-hours for 60 days of electric service. Divide 60 into 984 to find an average day's electric usage — in this case, 16.4 kilowatt-hours.

Bills vary for many reasons. Some of them are seasonal and time conditions over which you have little or no control. Others you bring about because you add new electrical appliances or replace old ones. Of course there are changes in living conditions . . . new members added to the family, older ones moving away, new energy-consuming hobbies, and a variety of other reasons. Too, the way you use your appliances can be either efficient or inefficient.

Another reason for changes in your bill is that electric rates are on an upward trend because of increased costs for nearly everything necessary to provide you with electric service — especially fuel oil for generating plants.

Setting Up Your Electrical Budget

You need to know how electricity is used in your home before setting up an electrical budget. An examination of past bills will help you determine this. From the bills you can see how many kilowatt-hours you used and also get a good idea of how many kilowatt-hours you use per day.

In deciding where you can reduce your use of electricity it may be helpful to inventory your home to learn where it is used. List the appliances and equipment in each area of your home; refer to the chart on the next page to help estimate the kilowatt-hour consumption. Since many appliances are not used every day or are used only for a short time, showing monthly rather than daily use may be easier.

For lighting and appliances not listed on the chart, you can calculate energy use. The number of watts consumed by light bulbs and appliances is marked on the nameplate. (If not marked in watts, they are marked in amperes. To find the watts, multiply amperes (amps.) times volts. For example: an appliance rated at 3 amps. multiplied by 120 volts would be 360 watts.)

To find the kilowatt-hour consumption, multiply the wattage by the number of hours or part of an hour the appliance is used. This number (watt-hours) divided by 1000 gives kilowatt-hours (KWH).

Example: a kitchen light with two 75 watt bulbs, on 2½ hours per day:

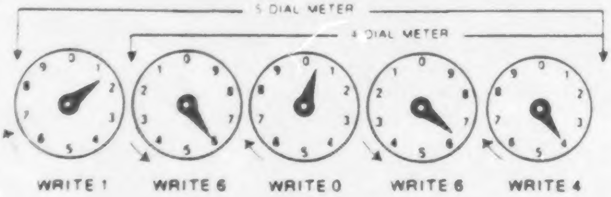
2 bulbs x 75 watts = 150 watts
150 watts x 2½ hours = 375 watt-hours per day
375 watt-hours — 1000 = .375 KWH per day
.375 KWH x 30 days = 11.25 KWH per month

Please note that electric appliances which are controlled by thermostats (refrigerator, range, skillet, iron, blanket, etc.) do not use electricity the entire time the appliance is on (the thermostat "cycles" the appliance on and off to maintain the desired temperature). You should estimate the time the electricity is on or preferably refer to the chart which shows average uses.

How To Read Your Meter

You may wish to read your electric meter, record the readings, and compare from day to day, or week to week, to determine for sure if you are saving electricity.

The dials are like watch faces lined in a row (every other dial moves counterclockwise). The reading for a five dial meter would be 16,064. The reading for a four dial meter would be 6,064.



Notice that when the pointer is between two numbers, you should record the lower of the two numbers.

When the pointer seems to be directly on a number, look at the dial to the right; if the pointer on the right side dial has passed "0", then write down the number the pointer seems to be on; if the pointer on the right side dial has not passed "0", then write down the previous lower number on the dial you are recording.

To figure how many kilowatt-hours you have used in a time period, subtract the previous reading from the current reading.

ESTIMATED AVERAGE MONTHLY KILOWATT-HOUR
CONSUMPTION OF ELECTRIC HOUSEHOLD APPLIANCES

MAJOR ELECTRIC APPLIANCES

APPLIANCE	AVERAGE WATTAGE	AVERAGE MONTHLY	
		KWH	FREQUENCY OF USE
Clothes Washer	510	9	26 loads per month
Clothes Dryer	4850	87	26 loads per month
Dishwasher	1200	30	1 load per day
Food Waste Disposer	445	3	daily use
Freezer (manual defrost) 15 cu. ft.		100	continuous
Freezer (frost free) 15 cu. ft.		147	continuous
Furnace Blower 1/3 h.p.		60	5 hours per day, winter season
Heater (bathroom or portable)	1000	1	per hour of operation *
	1500	1.5	per hour of operation *
Microwave Oven	1450	16	18 minutes per day
Range	12200	98	3 meals per day
Range (with self cleaning oven)	12200	100	3 meals per day, 1 cleaning per mo.
Refrigerator-Freezer (manual) 12 cu. ft.		61	continuous
16 cu. ft.		109	continuous
Refrigerator-Freezer (frost free) 16 cu. ft.		150	continuous
20 cu. ft.		209	continuous
Room A/C 6,000 Btu	850	.9	per hour of operation *
12,000 Btu	1380	1.4	per hour of operation *
Swimming Pool Pump 1 h.p.		1.5	per hour of operation *
Television (black and white)			
tube	160	30	6 hours per day
solid state	55	10	6 hours per day
Television (color)			
tube	300	55	6 hours per day
solid state	200	37	6 hours per day
Trash Compactor	400	4	daily use
Water Heater (Electric)	4475	400	continuous

ELECTRIC HOUSEWARES AND SMALL APPLIANCES

APPLIANCE	AVERAGE WATTAGE	AVERAGE MONTHLY	
		KWH	FREQUENCY OF USE
Bedcovering	150	25	8 hours per day, winter months
Blender	300	less than one	4 minutes per week
Clock	2	1	continuous
Coffeemaker	600	8	brew 50 pots per month
Curling Iron	40	less than one	25 times per month
Frypan	1200	8	15 times per month
Hair Dryer (soft bonnet)	400	2.5	2 times per week
(hand held)	600	2	5 times per week
Iron	1100	5	2 hours per week
Knife	95	less than one	10 minutes per week
Mixer—(hand)	80	less than one	15 minutes per week
(stand)	150	less than one	12 minutes per week
Radio	70	.7	3 hours per day
Radio/Phonograph	110	9	3 hours per day
Slow Cooker	200	12	2 times per week
Toaster	1100	3	6 minutes per week
Toaster-oven	1500	8	toasting, 4 minutes per day oven, 2½ hours per week
Toothbrush	1	less than one	continuous charging
Vacuum Cleaner	630	4	6 hours per month

* The time of use varies widely for these appliances. To figure the cost for your household, estimate the number of hours used per month and multiply by the cost per hour.

HELP BALANCE YOUR ENERGY BUDGET

There are many ways to save energy. You don't necessarily have to give up using all your appliances to balance your energy budget, but it is important to cut down wasteful consumption. Here are some energy-saving suggestions:

YEAR ROUND ENERGY-SAVING MEASURES

- Insulate to reduce the energy needed for heating and cooling.
- Keep windows and doors closed and use weather stripping around them to cut down drafts.
- Close fireplace dampers to prevent air from rising up the flue and escaping to the outside.
- Draw draperies in winter to reduce radiated heat loss through windows, and in summer to reduce heat gain from the sun.
- Clean or replace filters. Clogged filters make your heating or air conditioning system work harder.

SAVE ENERGY IN WINTER

- Lower the thermostat to 65°. Just a 4° reduction can save as much as 28% in heating energy consumption.
- Reduce thermostat setting at night or when away from home during the day. In mild climates, turn the heat off completely and save more.
- Limit use of bathroom and portable electric heaters. Those without thermostats do not cycle on and off.

SAVE ENERGY IN SUMMER

- Set thermostat to off, or cool less than normal if you are away from home.
- Do not over-cool — maintain as warm a temperature setting as possible to minimize cooling costs.
- Shade window areas from direct sunlight with window awnings, trees or plants.
- Take advantage of the daily temperature cycle — open windows to draw cooler night air into house; close up during the day.

SAVE ENERGY BY WISE APPLIANCE USE

Refrigerator
- Check door gaskets on refrigerator for air leakage.
- Defrost manual defrost refrigerators when frost becomes more than ¼ inch thick.
- Keep condenser coils at bottom or rear of the refrigerator clean.
- During vacations, set refrigerators at warmer temperatures and leave fairly empty.
- When unused for long periods, refrigerators and freezers should be turned off, cleaned and left open.

Range
- Plan ahead and cook several dishes or whole meals in the oven at the same time.
- Use tight-fitting lids and match the size of the pan to the size of the elements.

Dishwasher
- Run the dishwasher only when full.
- Save almost one half of the energy used by turning off the dishwasher after the last rinse cycle is complete and let the dishes air dry.

Clothes Washer and Dryer
- Wash and dry only full loads.
- Use warm or cold water for most laundry, except whites or heavily-soiled clothing.

- Turn off lights and other appliances, such as televisions and radios, when not being used.

MAKE EVERY KILOWATT COUNT!

Southern California Edison SCE

ENERGY AUDITING

Unit E_{VI} (Approximate Grade Level #6)

OVERVIEW

Students will gain a further insight into the interaction of the use of energy and the way we live our lives by carrying out an energy audit of their school, homes, and community.

LEARNING OBJECTIVES

The students will develop an appreciation of how their school, home and community use energy. This will be done by student conducted energy audits of the amounts of energy used, and where possible, the time of day of the need.

SPECIAL MATERIALS

Students will prepare a special worksheet

VOCABULARY

Demand, Kilowatt-hour, Rate

EXTENSION ACTIVITIES

An interesting activity might be for the students to calculate the total amount of energy their survey showed the user needed. Then have the students assume that there is a cutback in energy availability of at least 10%. Have the students make suggestions of how the user might be able to change his energy use patterns to live with the new amount of energy.

LESSON PLAN

1. Have the students first prepare a special energy audit sheet.

2. Enlist the aid of the school administrators, plant, and maintenance personnel in the activity of the students.

3. The audit sheet could be of the following design:

USER______________________________ LOCATION________________________________

ENERGY USE ITEMS (1)	POWER NEED (2)	HOURS OF DAY USED (3)	AVERAGE KW-HRS (4)

1. The user and location are obvious to fill in.

2. Column (1) could be obtained by visual inspection or given to the students by the person in charge of the facility. In either case, it is recommended that the students see at least some of the items so that they will have a better appreciation for what they are.

3. Column (2), the power need or requirement is the figure given on a metal plate on the item. It will usually be given in terms of watts.

4. Column (3) can be obtained by interviewing the person in charge of the facility or estimation (this would usually be the case for home audits). If possible this column should be done not based on average hours per day, but also the particular hours of the day it is used.

5. Column (4) is calculated by taking the number of column (2) and multiplying it by the hours of column (3) to obtain kilowatt-hours. This can be done for the day as a whole or preferably in terms of morning hours, afternoon hours, and night hours.

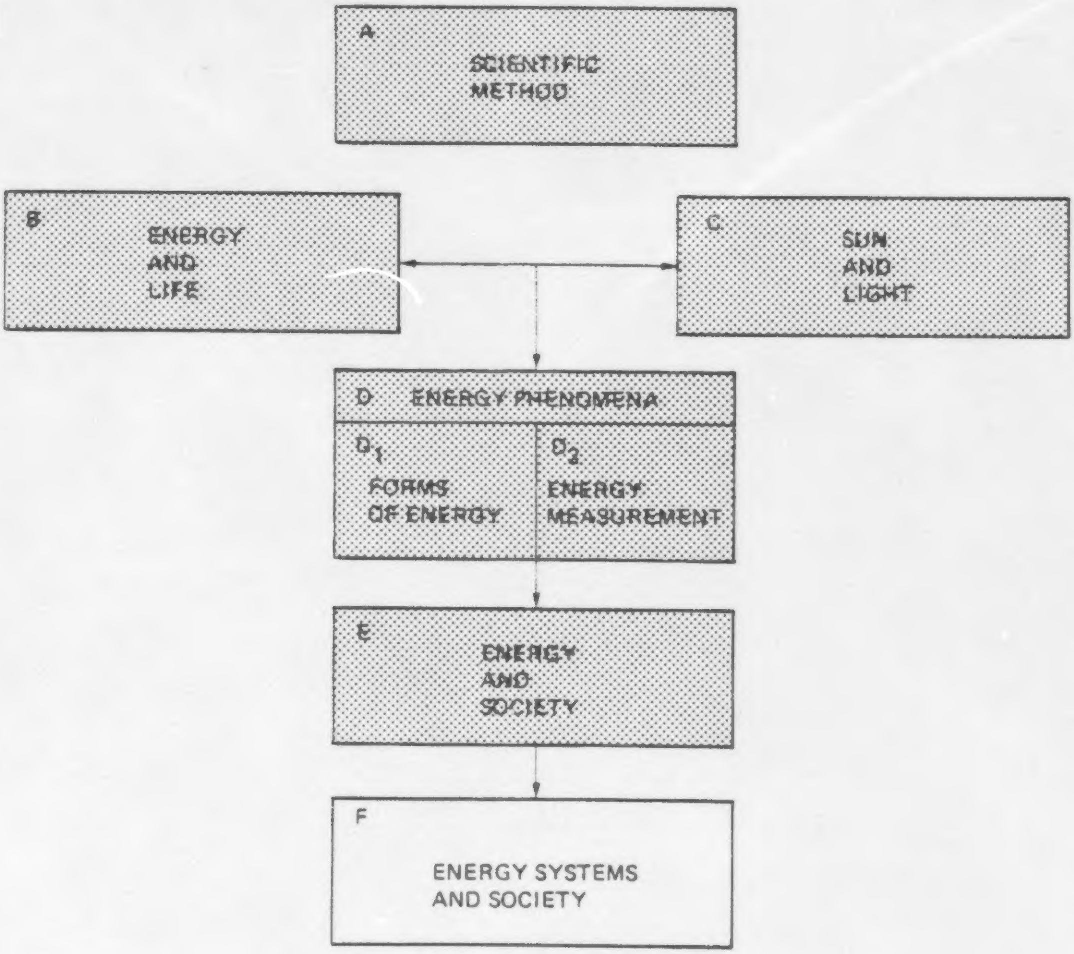
6. The students could also find out the rates of the area, that is the cost of a kilowatt-hour of electricity. This figure may be different for different times of the day. An additional column could then be set up to determine daily or hourly costs.

7. After the form is completed to the satisfaction of the class, a discussion could be held on how the energy is used. Are there any suggestions on how energy might be conserved or used in a different manner to make more use of energy off of peak demand times?

8. In general the class and user of the electricity should be able to carry the project as far as they feel will be of benefit to all. It is possible that the students could make some very good energy conservation suggestions.

9. The project could also be carried out for the student's homes, with the cooperation of the parents.

10. The students could also estimate the energy audit for the community as a whole.


A
SCIENTIFIC METHOD
B
ENERGY AND LIFE
C
SUN AND LIGHT
D ENERGY PHENOMENA
D_1
FORMS OF ENERGY
D_2
ENERGY MEASUREMENT
E
ENERGY AND SOCIETY
F
ENERGY SYSTEMS AND SOCIETY

SOLAR ENERGY CONVERSION SYSTEMS
HISTORY OF USING THE SUN TO MAKE THINGS WARM

Man has always had a very close relationship with the sun. Not only is the sun absolutely essential for the survival of man on earth (or for that matter, the earth itself), but many also has a strong affection for the life giving energy from this great glowing glob of gas.

Many ancients worshiped the sun as a god and the Greeks, on a much more practical scale, utilized the sun to keep their villages warm. It seems that the main source of energy for the Greek society was wood. As wood became scarce and had to be imported, such great Greek philosphers as Socrates, delivered lectures on utilizing the sun in a "passive" manner to warm their homes. The word "passive" refers to utilizing the sun's energy in a way that does not require any external input of energy; that is, no pumps or other mechanical devices are needed.

The Romans, when they conquered the Greeks, also adopted their concepts of passive solar heating. They also brought in one new innovation, using transparent glass like materials over their window areas. The window covering reduced heat losses considerably from inside the building. When the sunlight passed through the window glass and heated the bath areas, the Romans were actually the first people to use solar heating to keep their swimming pools warm (not the folks in Beverly Hills).

When the Romans were conquered and the world went into the dark ages (no pun intended here), the use of the solar energy was suspended. However, when the Renaissance occurred, solar energy found its use again for the development of greenhouse technology to allow the full year round growth of citrus plants. The French have been one of the leaders in solar energy research in modern times. In the year 1747, a gentleman named George Louis Buffon, demonstrated that he could set fire to wood piles 60 yards away using solar concentrators that he constructed. (Buffon was demonstrating the legend of the battle of Syracuse. In the year 212 BC, the invading Roman ships were allegedly set afire by thousands of Greek Soliders reflecting sunlight from their shields onto the ships.)

The French also had an energy problem similar to that which the United States is experiencing today (and also which the Greek government experienced two thousand years ago).

The French economy was based on the utilization of coal. This coal had to be imported and consequently, the French were having a balance of payment problem because too much of their national monetary resource was being sent out of the country. In the nineteenth century, the French controlled the country of Algeria, which had a tremendous solar energy potential. They commissioned a French scientist, Augustin Mouchot to investigate the use of solar energy and develop solar energy machines. He did this and produced a technology that is still good today. In 1878, he and another French gentleman, Abel Pifre, ran a solar powered printing press at the national exhibits (they printed a paper called Le Soteil, the Sun). However, the French discovered a problem area that has plagued solar energy then and now. Economically, it was still cheaper for the French to import coal than it was to build the machines to utilize solar energy, so poor Mouchot was relieved of his position.

By the end of the nineteenth century, solar energy was an accepted form of producing hot water here in the Western United States. A system known as a bread box solar collector* was used in about 30% of the homes in the Pasadena area just before the turn of the century. A major problem of the bread box type collector was that there was a tendency for it to lose its energy very rapidly after sunset. This basic problem was caused by the fact that the collector and storage system were one in the same.

In 1909, Mr. William Bailey developed the Day and Night Thermal Siphon Hot Water Heating System which he patented.** This system separated the collector from the storage tank and was in essence the start of our modern solar energy industry with the advent of the Day and Night Thermal Siphon Hot Water Heating System. Solar energy continued as a thriving industry in the Pasadena/Monrovia area of Southern California.

By the early 1920's, thousands of homes were equipped with solar hot water heating systems. In 1923, natural gas and oil were found in great abundance in the local area. Signal Hill took on the appearance of a porcupine covered with oil well drilling rigs. The technology of solar energy was good, but on the economic side, it was cheaper now not to replace or repair solar energy systems. It was dollars and cents wise better to buy a whole new heating tank utilizing the new cheap fuel of natural gas.

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*Basically a black tank is placed in an insulated box. The side of the box is open, but covered with a glass sheet. Sun shines in the box and warms the black tank. A bread box collector, because of the insulated box, can heat water to a temperature in excess of 120°F on sunny days.

**Mr. Bailey and his associates started the company called Day and Night. The concept behind the name was that you collected energy from the sun during the day and had it available for use at night. The Day and Night Company is still in existance today as part of the Carrier Corporation and after a period of many years, has re-entered the solar energy market place.

The entire solar energy industry was sold under license and moved to Florida. There was no cheap fossil fuel sources to complete and the solar energy industry again thrived until the Second World War. Many of the solar systems were still in operation in the 1950's.

After the Second World War, the availability of cheap fossil fuel in this country made the use of solar energy devices economically unattractive. Consequently, the development of and the use of solar energy in the U.S.A. came to a grinding halt. Other countries that did not have these cheap fossil fuel sources such as Australia and Japan, did continue to use to some degree solar hot water heating systems.

A very sad commentary might be that in the short period of time from 1923 to the present, this country has used so much of its natural resources of oil and gas that now we must buy and import our fossil fuel at every increasing prices. As a result, today solar energy is again becoming economically competitive for certain tasks, such as solar hot water heating.

Converting Radiant Energy Into Heat

Energy is considered the ability to do work; energy can take many forms. We can have light energy, heat energy, mechanical energy, electrical energy, etc. If one were to set up a hierarchy of the most important energy forms in relation to the earth, light energy would no doubt be at the head of the list. One could present arguments to show that all energy forms we have on earth can be traced back to the sun. For example, all of the fossil fuels that we have on earth could have their origin traced back to the sun. These fuels are the results of ancient vegetation and animal life that existed through the courtesy of "Mr. Sol".

The light energy which we receive from the sun depends upon many factors. Such things as the size of the sun, the distance the sun is from the earth, and the surface temperature of the sun all help to define the amount and kind of light energy we receive here on earth. In the case of the sun, the surface temperature is about 6,000 degrees Kelvin (°K) (degrees Kelvin refer to an absolute temperature scale). At zero degrees Kelvin, everything will become so cold that all atomic motion will cease. The temperature of water freezing occurs at 273°K. A simple connection can be made between degrees Kelvin and degrees Celsius. Zero degrees Celsius is where water freezes. Therefore, to go from degrees Celsius to degrees Kelvin, we simply add 273.

Objects appear white to us when they reflect the majority of all the sun's energy that is falling on them. Very little of the energy is absorbed by the body and it stays relatively cool. Things appear black to us when very little radiation is reflected from the surface of the object back to our eyes. In the case of black objects, they become very hot since the majority of the light energy is absorbed and transferred to heat energy.

Simple Solar Collectors

We can form a simple solar collector by the painting of a pop bottle black. In this case, the sunlight will fall on the black painted outside of the pop bottle. If the bottle is filled with water, the light energy that is converted into heat will be transferred into the water inside of the bottle. Then based on the local conditions, i.e., how cold it is outside, the amount of wind blowing, etc., an equilibrium will be set up between the amount of light energy coming into the bottle and the amount of energy being lost by the bottle. You will find on a good summer's day the bottle of water might get about 100°F temperature.

If our desire was to obtain water in the range of temperatures 90 to 100 degrees Fahrenheit, this simple painted black bottle would be all the solar thermal system we might actually require.

Swimming pools only normally are heated in the range of the mid to low 80's °F. Consequently, swimming pool solar thermal systems can use a very simple collector. Nothing more is needed than a series of pipes that are attached to a black material that absorbs the sunlight and then transfers this energy into the waterways. As long as there are no excessive winds in the area, this solar system normally works quite well to heat swimming pools.

Absorber Plate Construction

In the case of the painted black bottle, we can easily visualize that whenever the sunlight strikes the surface of the blackened bottle, that sunlight can very easily be converted into heat energy. The heat energy, in turn, transfers into the water. As we are visualizing, imagine taking the round pop bottle and make it into a shallow flat tank that is very wide and very long, but perhaps only a fraction of an inch thick. Now you can see that if we fill this with water, we will have a large surface area to intercept the solar radiation and a large area to convert the light energy into heat and transfer into the water. As a result, the water should very quickly come up to temperature. If we were now to make holes at the top and bottom of this very flat container, so that heated water was taken from the top and new cold water added to the bottom, we would have a good solar thermal collector.

However, this design is difficult to construct in a way that would allow a smooth flow of water all over the solar collector. Another design could be to take a large sheet of copper. Serpertine copper tubing along the surface of the copper sheet and solder it into place. Then paint the whole assembly black (See Figure F-1). Another method of absorber plate construction might be to have a series of tubes all coming together at the top and the bottom into larger tubes we call headers (See Figure F-2).

The various types of construction of absorber plate all have certain advantages and disadvantages. The more water area we can have in contact with the metal surface, the quicker we can have the energy transferred into the water. In the case of the blackened copper plate

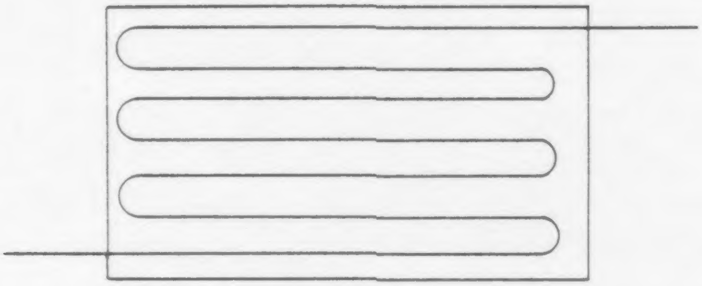

Figure F-1. Serptine Waterway Collector Design

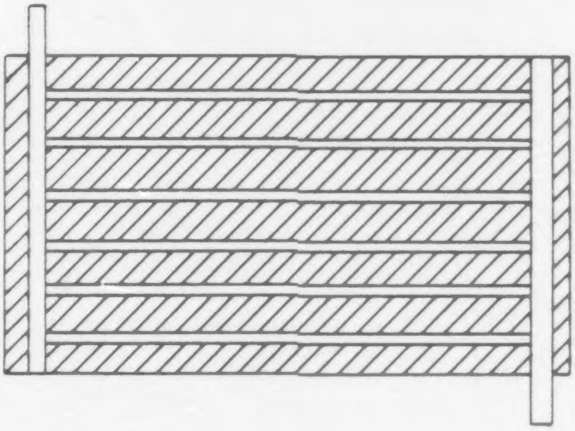

Figure F-2. Parallel Waterway Collector Design with the serpertine pipe, the copper sheet is first heated by the sun. The heat energy must then conduct itself through the copper and finally into the water ways. If the copper tubing is very thin and has many turns to it, this will cause a great deal of friction as the water moves through the pipe. There will be a large pressure drop through the collector. Parallel water ways do not have so much friction involved with them. However, if the pipes are widely spaced so that there is much metal between each one, the efficiency of getting the converted light energy into the water tubing may not be as great as if the parallel copper pipes are closely spaced. These problems of technology must also be moderated with the every day problems of economics. Closer spacing of the copper tubing requires more copper tubing to be used. This collector will be more expensive than a collector with wider spaced water ways. Modern solar collectors generally have compromised to a spacing of water ways to the order of 6 inches.

Solar Thermal Collector Designs

We may now ask the question, what if we wish to obtain temperatures that are higher than 100°F as we can get with our painted pop bottle or other bare absorber plate design? Then we must find a way of not letting the energy escape from the absorber plate. We put insulation around a frame and on the backside of the collector. This insulation will inhibit heat from being lost. The inside of the insulation has a coating of aluminum foil that will reflect radiant energy back into the collector, (the radiant energy that is being sent out by the collector itself).

To keep the winds from blowing over the top of the collector, we will use a glazing. This will produce a "dead air space" that will tend to keep energy from being convected away from the surface of the collector.

We can improve the design of the collector to obtain higher temperature. We can increase the amount of insulation around the sides and back of the collector. We can have more than one glazing over the front of the collector to obtain a series of dead air spaces.

Solar Thermal Energy Systems

To have solar energy systems actually produce hot water or other useful tasks for us, the collector must be part of a "system". Solar thermal systems are always composed of at least three components and sometimes four. The three basic components of a solar thermal energy system are: 1) the collector; 2) some type energy storage; and 3) a method of transporting the hot water to where it is needed (we say hot water, but this could be any fluid transferring the heat energy where it is required). We have already discussed the solar collection component of this system. Let us now look at the storage system.

The simple painted black pop bottle was a combination of collector and storage. If we take a tank, paint it black and then place the tank in an insulated box with a glazing over the surface, we have constructed what is known as a "bread box" solar hot water heating system. The sunlight shines in through the glazing and heats the tank of water. The insulation and glazing then tends to stop the tank from losing excessive amounts of energy and the hot water heating system can obtain temperatures in access of 120°F. However, this system only functions well when the sun is shining upon it. Heat energy tends to flow from locations where it is hotter to locations where it is colder. During the day, the sun is hotter normally than the water and consequently, there is a flow of heat into the tank. However at night time, this is not the case. On a clear cold winter night, the sky, as far as radiation loss is concerned, can look very, very cold. As a result, the tank radiates its energy away very quickly when the sun sets. We can improve on the bread box design by going out and manually putting an insulated cover over the surface of the glazing when the sun is setting.

Mr. William Bailey made a major breakthrough in solar collector design when he separated the collector from the tank with thermal-siphon hot water heating system. (See Figure F-3). Now when the sun set, very little water was actually in the collector itself, and consequently, very little energy was lost. The majority of hot water was in the well-insulated tank and only lost approximately 1°F per hour. It should be noted that energy loss from a storage tank depends on the surface area of the tank, the amount of insulation around the tank, and the temperature difference between the hot water on the inside of the tank and the air surrounding the outside of the tank.

Referring to Figure F-3, we can explain the thermal-siphon action of the heating system. Just as hot air rises amongst cold air, hot water will also rise amongst cold water. In a tank, we term this as "stratification". The cold water in the tank "falls" to the bottom of the tank and out through the piping to the lower end of the solar collector. There the water is heated by the action of the sun on the solar collector and starts to rise upward. As it goes through the

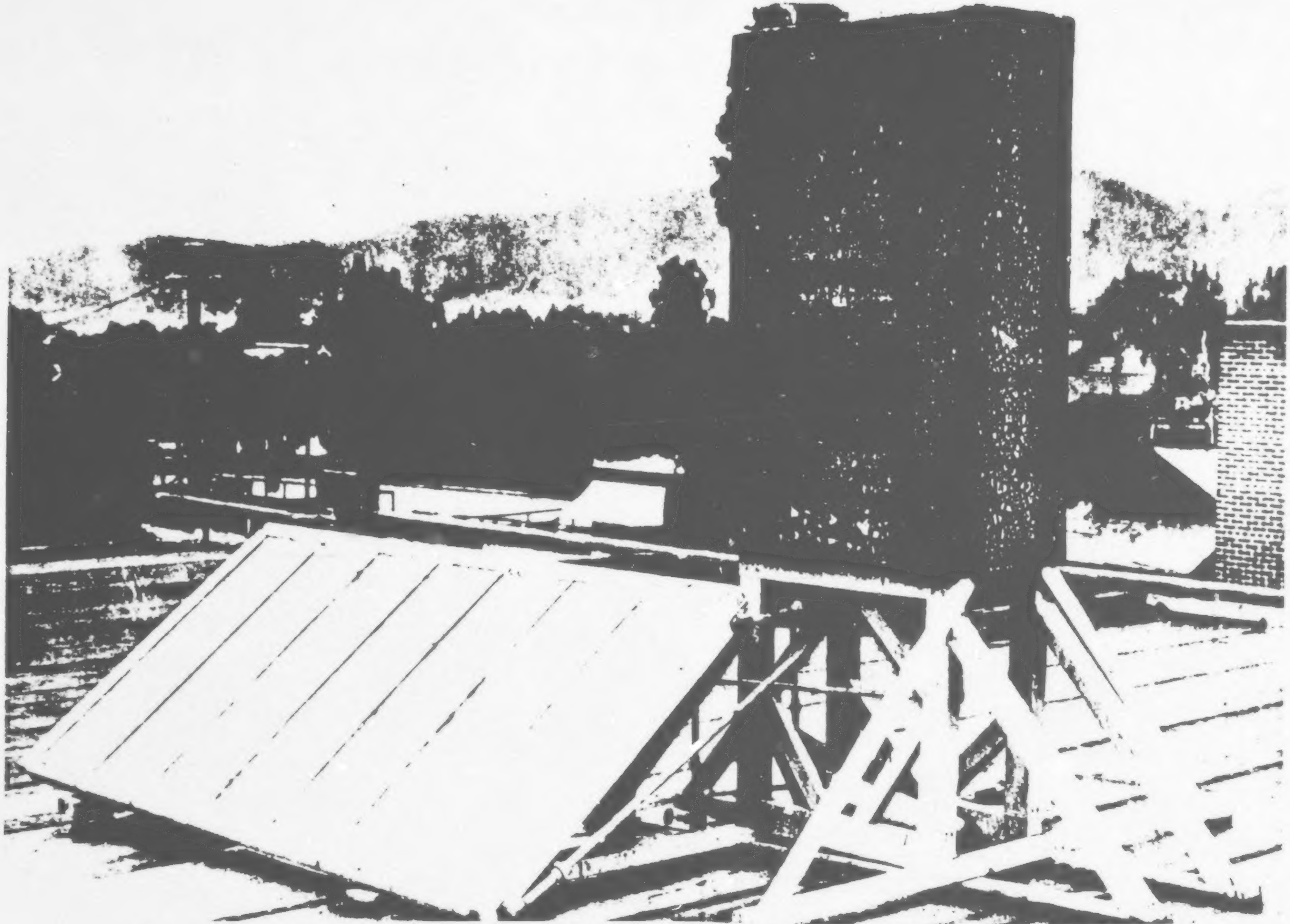

Figure F-3. Day/Night Thermo-siphon Hot Water Heating System (Photo Early 1920's) collector, it is continually heated and continually rises. Eventually, the water flows out of the top of the collector into the top of the tank. The top of the tank heats more and more, the cold remaining water is forced to the bottom of the tank and the system continues. On a bright sunny day, thermal-siphon hot water heating systems can have the water circulate at the rate, perhaps, one gallon per minute (i.e., with the normal size home hot water heating system).

The fourth component of the system is some form of "control". We apply one element of "control" to the thermo-siphon system by making sure that the tank is the order of 18 inches to 2 ft above the solar collector. Otherwise, when the sun sets, the system would reverse and the hot water would then be continually cooled by radiation away from the collector to the cold night sky.

Many home owners today do not wish to have the combination of solar collector and tank on their roofs. In fact, many of the roofs are not constructed in such a way to support the weight of the tank. As a result, many of the solar systems today follow the design of Figure F-4. Here the collector is placed on the roof, but the storage tank is now in some location such as the garage or laundry room. We cannot obtain a solar thermal-siphon circulating system and must introduce an electrically driven pump to circulate the water between the collector and the tank. The concept of control must now be exercised in a much more obvious manner. This can be done with such simple devices as a timer clock. This would turn the pump on during the hours of normal sunlight. Such a device would work fine in areas where there was normally clear,

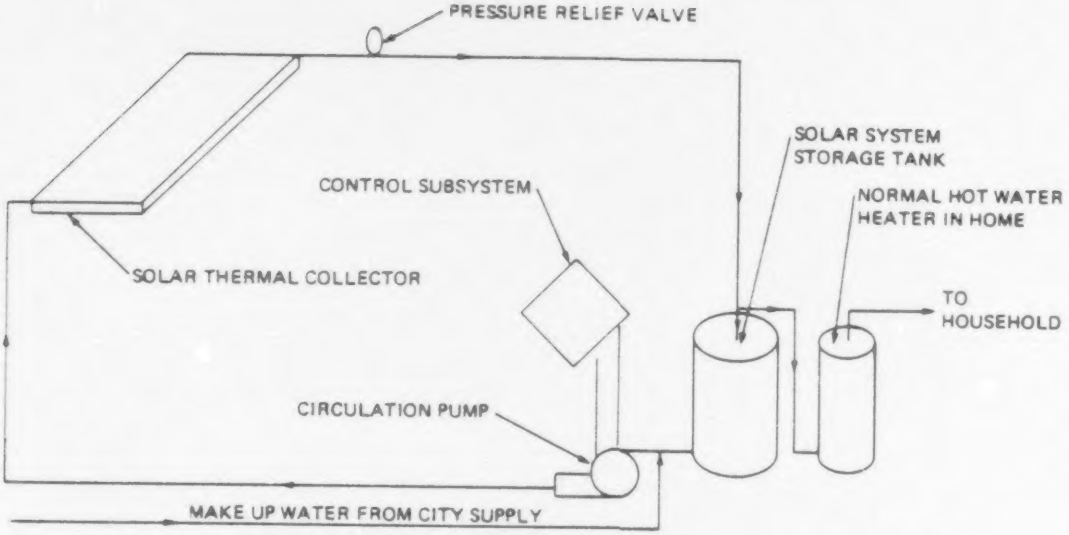
PRESSURE RELIEF VALVE
SOLAR SYSTEM STORAGE TANK
CONTROL SUBSYSTEM
NORMAL HOT WATER HEATER IN HOME
SOLAR THERMAL COLLECTOR
TO HOUSEHOLD
CIRCULATION PUMP
MAKE UP WATER FROM CITY SUPPLY

Figure F-4. Pumped (Active) Solar Thermal Hot Water Heating System

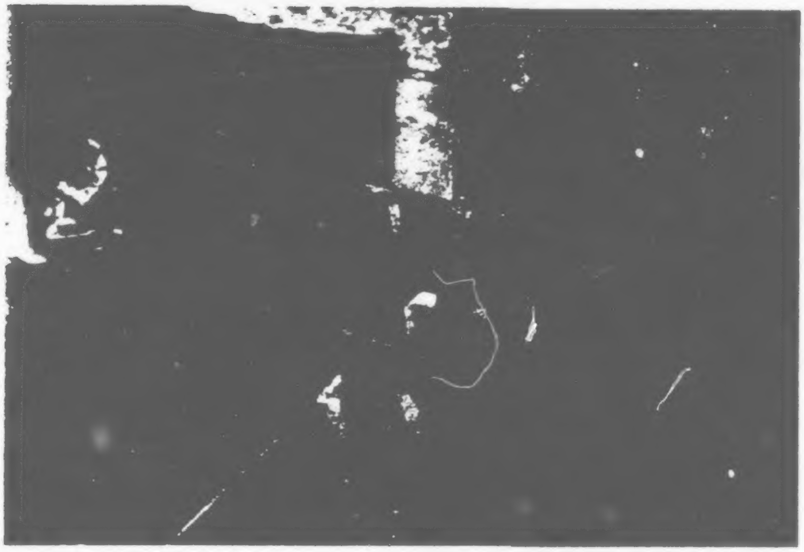

Figure F-5. Small Thermo-Siphon Hot Water Heating System cloudless skies. However, this type of condition is becoming harder and harder to find in our modern society. Control is also needed to prevent system damage due to freezing or overheating.

Other forms of control systems have, therefore, been introduced. One could use a simple photovoltaic cell (that is a solar device that directly converts sunlight into electricity) that could control a relay which, in turn, would turn the pump motor on and off. Another method of control system is a "differential thermostat" In this system, temperature sensors are placed at the bottom of the storage tank, the location of coldest water and at the top of the collector, the location of hottest water. A small microprocessor then continually compares the two temperatures. If the temperature at the collector is hotter than the temperature at the storage tank, the system can gain energy and the pump motor is turned on. If the reverse is true, the storage tank could only lose energy and the microprocessor keeps the pump motor in the off position.

Sizing of Solar Systems

Before we can conclude our discussion of solar thermal systems, we must cover the topic of sizing. That is, the determination of how big the solar collector should be and what size the storage tank should be in correspondence to the collector. This task is accomplished, not by starting with the collector and working downward, but by looking at what energy requirement is to be taken from the storage tank (e.g., how much hot water would be required by a family during the day). Studies have shown that each member of a household requires between 15 and 25 gallons of hot water per day. The actual amount depends on how many showers the family takes, the amount of clothes washing required, the types of water use appliances in the home, and many other factors. One first determines the size tank to accommodate this demand or some fraction of it (economically doing about 2/3 of the demand with solar has been found most satisfactory). It has been found through practice that as a rule of thumb, one should have approximately one square foot of solar collector for each 1.5 gallon of hot water required in the storage tank. This number is flexible, in actual fact. In practice, one may find systems designed where there is one gallon of storage water for each square foot of collector to, perhaps, other systems where there is as much as 2 gallons of storage for each square foot of collector. Obviously, the more collector area in relation to storage tank, the quicker the hot water will be heated.

Photovoltaic Solar Systems

For a brief explanation of what a "solar photovoltaic" device or solar photo cell is, the reader is referred back to the short write-up discussing the "Sunstor" solar battery charger. A photovoltaic solar energy system produces electricity from sunlight, rather than heat energy as in a solar thermal system.

The main components of a photovoltaic solar system are the same in concept as with a solar thermal system. The solar collector collects the solar energy (the sunlight) and converts it directly into electricity. The electrical energy can be stored in a storage battery, and the electricity can be transported to where needed via wires. The control function would be accomplished by a voltage regulator that would control how the battery was being charged.

While for all practical purposes a solar thermal system is always used in conjunction with an energy storage component, this may not be the case with solar photovoltaic systems. A good example might be an electrically driven water pump. This device would be designed to operate only during daylight hours. The electricity from the solar photovoltaic collectors would be sent directly to the pump. This sort of system would also be self-controlled. That is, when the sun was not out or the weather was cloudy or overcast, not enough electricity would be produced to run the pump.

SOLAR ENERGY SYSTEMS

Unit F_{IV} (Approximate Grade Level #4)

OVERVIEW

(It is suggested that the teacher read the supplied background information on solar energy systems before conducting this lesson.) The students are introduced to the concept of a basic solar energy collector, a method of storing the collected energy in some form to be used later, a method of transporting the stored or directly collected energy to where it is needed, and some method of controlling the overall system operation). The students will perform simple experiments, some of which may have been done in previous lessons but this time the students analyze the various functions that are going on. The simple experiments are: 1) painting jars with certain colors and examining the final result as a "solar energy system", and 2) optional experiments utilizing the solar hotdog cooker and/or the sun store battery charter.

LEARNING OBJECTIVES

The students are introduced to the concept of solar energy system, and experiment with various simple devices to better understand the individual role of each "component" in the overall "system".

EVALUATION

The students will achieve a basic understanding of a "solar energy system" and the various major components comprising it. This evaluation can be achieved by having the students draw a picture of a solar system pointing out the individual components.

SPECIAL MATERIALS

- Two or three empty jars (small size soda pop bottles will be ideal)
- Necessary materials for rach student or teams of students to individually construct "10c hot dog cookers". (optional)
- Sunstor solar battery charger (optional)

VOCABULARY

Collector, Storage, Transport, Control, System

SPECIAL NOTES

This lesson in general is considered very beneficial from the standpoint of teaching the students the art of observation and logical thoughts about things in our everyday lives. We can look at many tasks or jobs we do using a "system approach". This is simply a matter of analyzing how we do things step by step, to achieve a method of accomplishing a task in a most efficient manner. Even the simple task of writing on paper can be approached as a system, e.g., the most effective way of holding the pencil, the best angle that the paper should be turned on the table, the proper pressure applied during writing, and any other specific component that may be of prime importance. As follow-up activities, the students can pick a system of their own choosing and write a small essay listing the various components of the system and what the various tasks are that the components accomplish.

LESSON PLAN

1. Carry out the motivation. Stress to the students the individual role of each component in the catapult. Encourage a discussion on how big or which eraser should be used, how hard one should hit the ruler, etc.

2. Carry out a blackboard study of a solar energy system in the following manner:

    Ask the student what will be needed to make a system that will collect sunlight, keep its energy and let us use it later on? The discussion will have to be led, no doubt by the teacher. Have the teacher lead the discussion so that the students will see that the things needed are: 1) a collection component to catch the sun's energy and convert it into some other form that we can store (e.g., heat into water, electricity, etc.). A second component will be someway of storing that energy (a hot water tank, batteries, etc.). The third component will be some "transport subsystem" that will allow us to take the energy we have stored and put that energy where we will need it (e.g., pipes for a hot water tank to shower, wires from a battery to a light, etc.). The last and fourth major component will be some form of "control". That is a method of making sure this system works properly (e.g., turning on a pump to circulate water from a tank to the solar collector, turning on a switch to allow current to flow from the battery to the light, etc.)

3. The teacher will show the students the glass jars and ask, "Can we make these glass jars into solar energy systems?"

4. If the students paint the outside of one of the jars black so that it will absorb the sunlight and convert it into heat energy, they will make a "solar collector". If then they fill the jar with water and screw the cap back on the jar, that will also be a solar energy storage system, i.e., the outside paint and glass will be the solar collector, it will get hot and the solar energy will be transferred as heat into the water and stored inside the jar. Later the students, using care not to burn their hands, can pick up the jar, bring it in after it has been in the sun and warmed and use the hot water where they need it, i.e., they will become the transport component. Question: What about the control component? If the students paint half the bottle black and half the bottle white, then only part of the jar will be a solar collector and the final temperature of the inside water after a specific period of time will not be as hot (this form of control painting is one way spacecraft have their inside temperatures controlled).

5. Have the students paint one jar completely black. Have them paint another jar completely white. A third jar should then be painted in some pattern so that approximately half the jar is white and half the jar is black.

6. After the paint has dried, carefully fill the jars with water and replace the caps.

7. Place the jars in bright sunlight for approximately 30 minutes (the specific time placed in the sun can be determined to obtain a maximum effect of the experiment). After the specific time has elapsed, have the students go outside and measure the temperature of the water using a thermometer. What are the temperatures? Are they different? Has our painting the jar white or partially white controlled the temperature of the inside water?

8. The experiment can be repeated using different forms of patterns on the jar and letting the jars sit in the sun for different periods of time.

9. The students can each make, as an optional exercise, a 10¢ solar hotdog cooker. Have the students analyze how the hotdog cooker works in relation to a solar energy system. The sunlight is collected over an aluminum foil surface. It is then reflected onto the hotdog itself. The hotdog then absorbs the solar energy and stores it inside the skin of the hotdog. As more energy is stored, the temperature of the hotdog increases and eventually cooks. There are actually two forms of transport of energy here. The light energy is reflected onto the hotdog and is transported from the aluminum surface to the hotdog by optical methods. Once the hotdog cooks, it is transported to by mechanical methods (the students' hands). The control is accomplished by how well we aim the hotdog cooker to the sun and how long we allow it to sit and collect the solar energy.

10. Another optional adjunct to the lesson can be the demonstration of the sunstor battery charger. The photovoltaic solar cells act as a solar energy collector. They convert the solar light energy directly into electricity and then the electricity is transported along the wires to the battery. The electrical energy is then stored inside the batteries in the form of chemical energy. We can then later transport that energy, i.e., take the batteries and carry them to where we need them to run such devices as toys or flashlights.

MOTIVATION

Pose the question to the students "What is a system?" (A system is a series of components or pieces put together in such a way that they will accomplish a certain task in the most efficient manner.) The teacher can illustrate a concept of a "system" using a very simple device such as a small catapult constructed by laying a ruler on top of an eraser. A small piece of chalk can be put on the downside of the ruler and when the high side is struck, the chalk will fly across the room. The teacher can say the job that wishes to be done is to shoot the chalk as far as one can. To accomplish this task, the catapult is our "system". The various components of the system are the chalk, the ruler, the eraser, and the person who hits the ruler to fire the chalk. A study can be made to determine which side the eraser does the best job, where the eraser should be placed along the ruler, and how hard one should hit the ruler (so that the chalk does not go straight up in the air or hit the ceiling). This will be a "system study". The students will now be asked to do a system study in solar energy.

SOLAR ENERGY SYSTEMS

Unit F_V (Approximate Grade Level #5)

OVERVIEW

This lesson is an extension of E_V. Students will learn how to take simple absorbers (black painted bottles, food wrapped in foil then black paper, etc.) and by placing them in insulated boxes with glazing make a more powerful solar collector. The term "powerful" is utilized in this case to mean able to obtain a higher temperature. Students will use these new simple solar systems to produce higher temperatures for hotter water heating and food warming ovens.

LEARNING OBJECTIVE

Students are introduced to the concept of "shielding" the absorber of solar energy from the environment around it that tends to want to cool it. This is done by placing the absorber in an insulated box (protects the absorber from wind and cooler temperatures at back and sides) with a transparent glazing over the front (provides a "dead air space" to act as an insulator but still allows the sunlight to beam on to the absorber).

EVALUATION

SPECIAL MATERIALS

- Glass jars
- Polystyrene foam picnic cooler
- Some aluminum foil
- Some black construction paper

- Sunstor solar battery charger (optional)
- A picnic type polystyrene food keeper (medium to large size)
- Some black construction paper
- Thumbtacks
- Transparent thin plastic wrapping material
- Small pop bottles that have been painted black

VOCABULARY

Absorber, collector, storage, "breadbox collector", glazing, insulation.

ACTIVITIES

- Review with the students the lesson F_{IV} to again bring to mind how dark colored items absorb the light energy of the Sun and convert it to heat energy.
- Have the students make a new series of black painted soda pop bottles (the students can alternatively paint the bottles any other dark color such as brown, dark green, etc. that they may consider more esthetically more pleasing).
- Put these bottles in the Sun to be heated by solar energy while the following other items are prepared.
- Take the picnic food keeper and either paint the inside black or line the inside with black construction paper. If you paint the inside be aware that some of the spray paints

will melt the polystyrene if put on in excess amounts. The construction paper can be installed using thumb tacks and small amounts of glue such as "Elmers Glue". Make sure you give the glue ample time to completely dry before you use the unit as an oven (otherwise the heat generated will go to simply dry the glue and the temperature will remain low).

- Take one of the painted bottles that are in the sunlight, and measure and record the temperature of the water (use a thermometer that can fit within the neck of the bottle and make sure the bottle has been in the direct Sunlight for 20 to 30 minutes).

- Lightly cork or stop the bottle so that fluid will not spill out.

- The question is now, "How can we obtain a higher temperature water than was arrived at by letting the bottle itself sit in the Sun?". The bottle should have arrived at a "equilibrium" temperature. That is, a balance will have been reached between the input of energy via the Sunlight and energy losses of the bottle (primarily by the outside of the bottle being direct contact with the cooler outside air, especially if there is any sort of a breeze or movement of the air about the bottle). The method must be to somehow "insulate" the bottle from the environment around it but still let the Solar Energy fall on it.

- Place the corked bottle inside of the prepared food keeper. Make sure the bottle is more or less standing upright. Place an oven thermometer (or what ever type you may have) also inside the food keeper in such a way that you can see it from the top.

- Take the transparent plastic wrapping material and using thumbtacks seal off the opening of the food keeper.

- Taking care not to tip over the bottle, place the food keeper with the bottle inside and the top sealed off in the Sunlight so that the Solar energy can directly shine in to the food keeper and fall on the bottle and other parts of that have been blackened.

- Observe how the temperature rises inside of the box by looking through the plastic wrap at the interior thermometer.

- When the temperature seems to be steady, carefully remove the plastic wrap, take out the bottle, and measure the temperature of the water. It should be many degrees hotter than when the bottle stood alone in the Sun.

EXTENSION EXERCISES

- As a more excited exercise the students can take food such as a hot dog, or other bit food that might want to be warmed before it is eaten. Wrap the item in foil paper and then wrap it again in black construction paper. Put this back into the food keeper, replace the plastic wrap "glazing", and let it stand in the sun for an hour or more. Periodically check the reading of the thermometer that is inside of the food keeper (by looking through the plastic wrap, but not removing it. How warm will this very simple solar oven become?

SOLAR ENERGY SYSTEMS

Unit F_{VI} (Approximate Grade Level #6)

OVERVIEW

Students are further shown solar energy systems. In this particular lesson they are introducted to components that are more what would be seen on the commercial market than as a home made project. Experiments are carried out by the students to better understand how flat plate solar thermal collectors operate.

LEARNING OBJECTIVES

This lesson is a continuation of the education of the student into the construction of flat plate solar thermal collectors. In particular students are shown a "commercial" design, and one of the objectives of the lesson might be considered consumer education.

SPECIAL MATERIALS

Special 8" x 8" solar collector or equivalent

VOCABULARY

Absorber, collector, glazing, insulation

ACTIVITIES

- Review with the students the lesson B.5.V. Have the students remake the devices used in that lesson.

- The solar collector system that initially was made in lesson B.5.V using the food keeper and black bottle is known as a "breadbox" solar water heater. This type of system was very popular before the turn of the century, and for that matter is still used by many people. One of the main problems with the unit is that the collection and storage subsystems are one in the same (i.e. the painted bottle is the absorber of the solar energy and it is also the place where the heated water is stored.). This is a problem because when the Sun is no longer beaming on the bottle, the water will very quickly cool down. When the thermosiphon hot water heating system was developed in 1909 (see The Solar System Background information supplied with the curriculum) the water was heated using a "flat plate" solar collector and then the heated water was stored in a highly insulated tank.

- Students can be shown the minature flat plate solar thermal collector, and pose to the class the question of how they think the internal parts are constructed.

- After a sufficient discussion, the side of the collector (the side with only two sheet metal screws) can be removed and in interior construction examined.

- Reassembly the collector and using a cork, stop up one end of the copper tube (this will now become the "bottom" of the collector).

- Fill the tube with water (i.e. the copper will now become a metal test tube with a solar collector attached to it) and place it in the Sun so that the glazed side is facing as directly as possible to the Sun.

300

- Using a long thin thermometer such as a laboratory thermometer or a meat thermometer for the oven, keep measuring the temperature of the water.

- Temperatures the order of 160°F to 180°F are not uncommon many minutes in the Sun.

- This temperature is known as a "stagnation" temperature and is the hottest value the collector is able to achieve (when the water is flowing in and out of a collector into a tank the total mass or volume of water is much higher, and therefore even if no water is used it will take many times longer to obtain near stagnation temperatures).

- Have the students now compare the temperatures obtained with the bare painted bottle, the painted bottle in the breadbox collector, and finally the temperatures of the flat plate collector. Have the students make lists of tasks that would require these different temperature (e.g. heating a pool or spa, heating hot water to bath in, and using hot water to heat your home).

- Have the students contact some local solar energy companies to obtain information about the solar collectors and systems that they market.

- Have the students bring their collective information to class. Have class discussions about the equipment. Compare it to the small solar collector used in the lesson.

- Have the students compare costs and in general discuss the purchase of a solar system as young consumers.

EXTENSION ACTIVITIES

As a continuation of the lesson, have the students continue to collect solar information. A file of solar equipment could be maintained. Have the students find local residents who have solar systems on their homes or business Have some of the students interview them and report their findings back to the class — Does the system perform well, how much did it cost, are the people happy with their purchase, why did they buy solar, why the particular system they have, etc.?

APPENDIX A

APPLICATIONS AND DEMONSTRATIONS MATERIALS

APPENDIX A

APPLICATIONS AND DEMONSTRATIONS MATERIALS

This Appendix contains most of the materials identified for use with the various lessons. Table A-1 lists the resources that are applicable to the lessons indicated.

Additionally a partial list of references are provided. For further information on any of the materials described herein please contact the Principal Investigators at the University of Southern California.

Table A-I. Applications and Demonstrations Materials

Section or Lesson	Type Material	Reference	Appendix Page #
A_I	Lab Report Work Sheet	Figure A-2	A-15
A_{II}	Deck of Sorting Cards P.P.E.C. Method	Figure A-3a, A-3b	
B_{III}	Multi-Purpose Photo Card Deck (Direct/Indirect Use of Sunlight)	Appendix A	A-4
C_I	Multi-Purpose Photo Card Deck (Direct/Indirect Use of Sunlight)	Appendix A	A-4
C_{II}	Reflection/Refraction Work Sheet	Figure C-4	
C_{IV}	Multi-Purpose Photo Card Deck (Alternate Energy)	Appendix A	A-4
C_{VI}	40 Slide-Set and Cassette "Viking Mission"	Demo Kit	
D_{1-K}	Ten-Cent Hot Dog Cooker	Appendix A	A-28
D_{1-I}	Ten-Cent Hot Dog Cooker	Appendix A	A-28
D_{1-II}	Ten-Cent Hot Dog Cooker	Appendix A	A-28
	Sun-of-Cell	Demo Kit	
	Kinds of Energy Worksheet	Figure D-3	A-20
D_{1-III}	Kinds of Energy Worksheet	Figure D-3	A-20
	Special Fossil Fuel Cycle Film Strip	Demo Kit	
	Ten Cent Hot Dog Cooker	Instruction Manual	
D_{1-IV}	Monopoly Set	Not Supplied	
D_{2-K}	Tri-Color Thermometer	Demo Kit	
	Thermometer Record Sheets	Figure D-8	A-26
	Ammeter Record Sheets	Figure D-9	A-27

Table A-I. Applications and Demonstrations Materials (Continued)

Section or Lesson	Type Material	Reference	Appendix Page #
D_{2-I}	Tri-Colored Thermometer	Demo Kit	
	Simple Radiometer	Demo Kit	
D_{2-II}	Tri-Colored Thermometer	Demo Kit	
	Simple Radiometer	Demo Kit	
	Special Card Deck - Tools/Mea Dev.	Figure D-10	
D_{2-III}	Special Thermometer	Demo Kit	
	Simple Radiometer	Demo Kit	
D_{2-IV}	Solar Cell/Meter Radiometer	Demo Kit	
D_{2-V}	Thermometer	Demo Kit	
	Solar Cell/Meter	Demo Kit	
	SunStor Battery Charger	Demo Kit	
E_I	Magnifying Glass	Demo Kit	
E_{II}	Looking at Energy Word Sheet	Figure E-1	
E_{III}	Special Film Strip Alternate Energy	Demo Kit	
	Alternate Energy Work Sheet	Figure E-2	
E_{IV}	Ten Cent Hot Dog Cooker	Inst.	
	SunStor Battery Charger	Demo Kit	
E_V	Film Strip - Energy Conservation	Demo Kit	
	Special Electric Meter Work Sheets	SCE Manual	
F_{IV}	SunStor (Optional)	Appendix A	A-21
F_V	SunStor (Optional)	Appendix A	A-21

MULTI-PURPOSE PHOTOGRAPHIC CARD DECK

The set of 19 photographs may be used as they appear on the page or cut into a card deck. The photos are part of the material used in lessons:

C_I B_{III} Direct and Indirect Uses of Sunlight

C_{III} D_I I_{II} Various Forms Energy Can Take

and are recommended as an adjunct to lesson:

C_{IV} E_{III} Alternative Energy Sources

It is hoped that the set of photos may prove versatile enough to find a much wider use by teachers in a variety of other and as thought motivation for the students.

CHARACTERISTICS

SLIDE NO.	DESCRIPTIONS	Direct/Indirect	Main Energy Forms	Main Environmental Impacts
1	Green Plants	Direct use of the sunlight in photosynthesis process	Solar radiant energy, chemical energy used in photosynthesis	Produces oxygen for us to breathe
2	Battery Charger Using Photovoltaic cells	Direct use of the sunlight in converting the radiant energy into electricity	Solar radiant energy, electricity, chemical energy	Environmental impact would have been production of pollutants when the plastic, photovoltaic cells, and batteries were manufactured.
3	Loaf of Bread	Indirect use of sunlight by utilization of the wheat grown in the fields	Bioenergy, heat energy used in baking.	Production of pollutants where all of the bakery utensils are washed.
4	The Skylab Space Station	Direct use of the sunlight by converting solar energy into electricity using the solar cells arrays.	Solar radiant energy, electricty	Production of pollutants when the equipment was manufactured and the rocket launched into space.
5	People riding a bicycle	Indirect use of solar energy by utilizing the energy stored in food to make the human muscles work.	Chemical energy, Mechanical energy	Pollutants produce when the bicycle was manufactured.
6	Car in motion	Indirect use of solar energy by utilizing the solar energy stored, ancient vegetation that has turned into oil.	Chemical energy, Mechanical energy	Pollutants produce when the car was manufactured; Pollutants and emission produce when the car runs.
7	Car at a gasoline service station	Indirect use of solar energy via energy stored in fossil fuels.	Chemical energy	Pollutants and emissions are given off when the gasoline is manufactured and put into automobile.
8	Parked Automobiles	Direct use of solar energy in heating the interior of the car.	Heat energy, solar energy	The cars become very hot inside.
9	Motorcycle	Indirect use of solar energy by utilizing the solar energy stored, ancient vegetation that has turned into oil.	Chemical energy, Mechanical energy	Pollutants produce when the motorcycle was manufactured; Pollutants and emission produce when the car runs
10	A solar collector	Direct use of sunlight to produce heated water.	Solar radiant energy, heat energy	Pollutants were produced when the solar collector metal was manufactured.
11	A wind generator	Indirect use of sunlight utilizing the wind produce in weather pattern, generated by solar energy.	Solar driven wind energy, heat energy	Pollutants were produced when the generator was manufactured.
12	A solar heated restaurant	Direct use of sunlight to heat the inside of Rick's restaurant in Denver, CO.	Solar radiant energy, heat energy	Pollutants were produced when the solar panels were manufactured.
13	The square tower pueblo in Mesa Verdes National Park	Direct use of sunlight to keep the building warm.	Solar radiant energy, heat energy	There was no environmental impact by using the square tower.
14	A fossil fuel power plant	Indirect use of solar energy by burning fossil fuel	Chemical energy, heat energy, electrical energy	Pollutants are put into the atmosphere when fuel is burned, heat energy is put into the ocean during the process of power generation.
15	A solar hot dog cooker	Direct use of solar energy to cook the hot dog.	Solar radiant energy, heat energy	Some pollutants were produced when the materials used to make the solar cooker were originally manufactured.
16	Magnifying glass	Direct use of concentrated solar energy to burn paper	Solar radiant energy, heat energy	Pollution produced when the glass was manufactured.
17	An electric light	Indirect use of solar energy by utilizing fossil fuel to produce electricity which in turns lights the electric lamp.	Radiant or light energy, heat energy	Pollutants and emissions were produced when the electric light was manufactured, and power plant pollute the atmosphere producing electricity.
18	A green house	Direct use of the sun's energy to make the plants grow.	Solar radiant energy, chemical energy	Some pollutants and emissions were produced when the materials used to make the green house were manufactured
19	Hoover Dam	Indirect use of solar energy via weather conditions	Potential energy	Pollution caused when the dam was constructed

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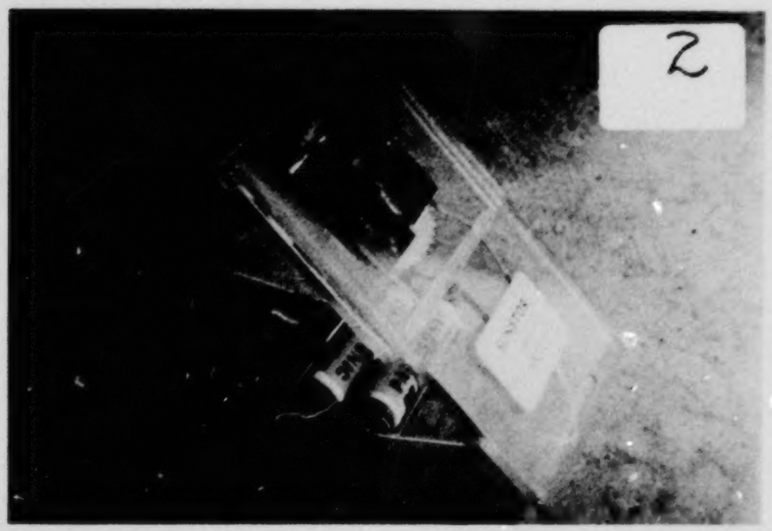
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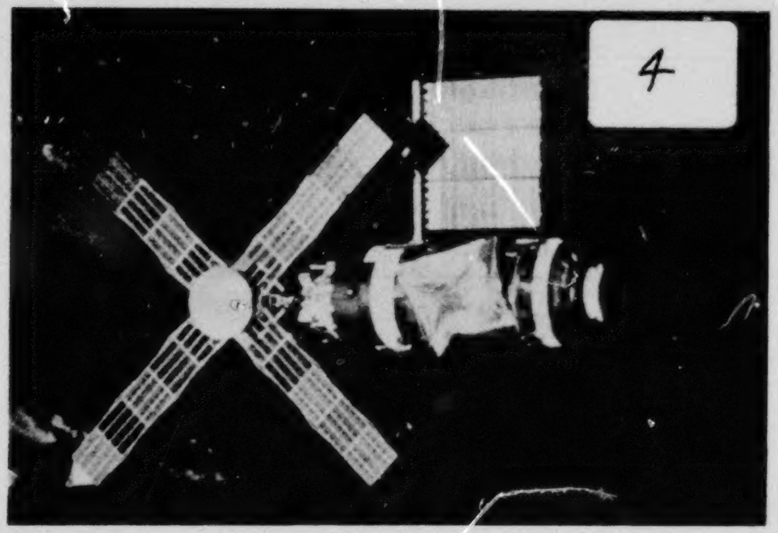
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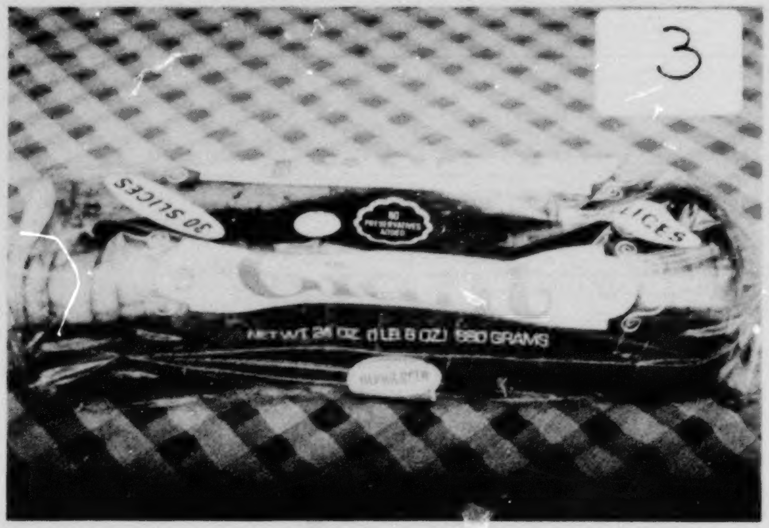
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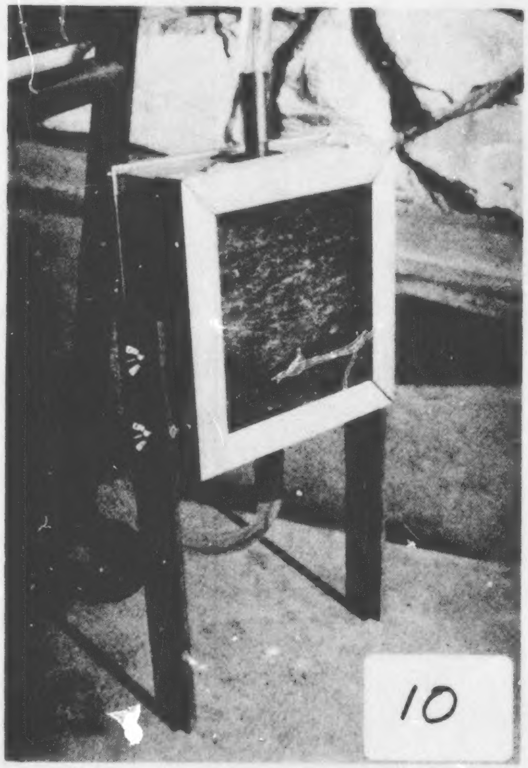
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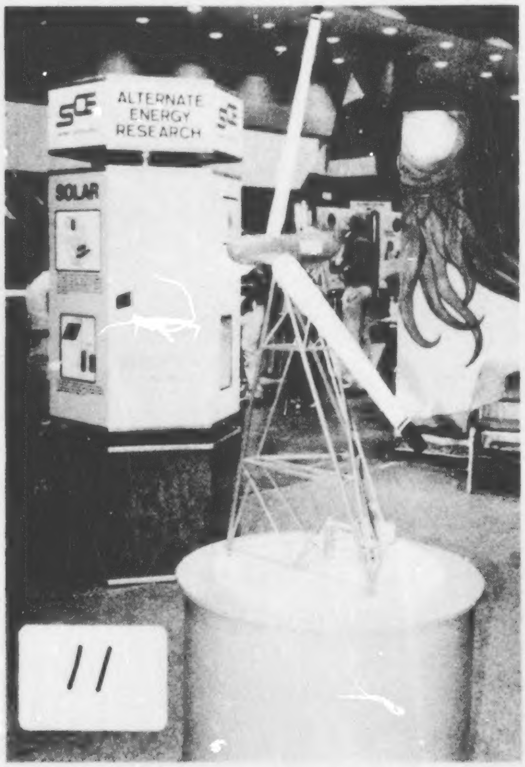
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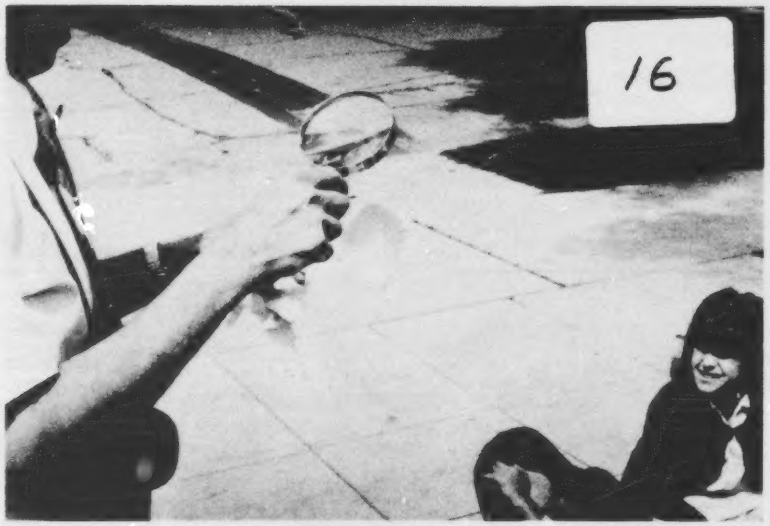
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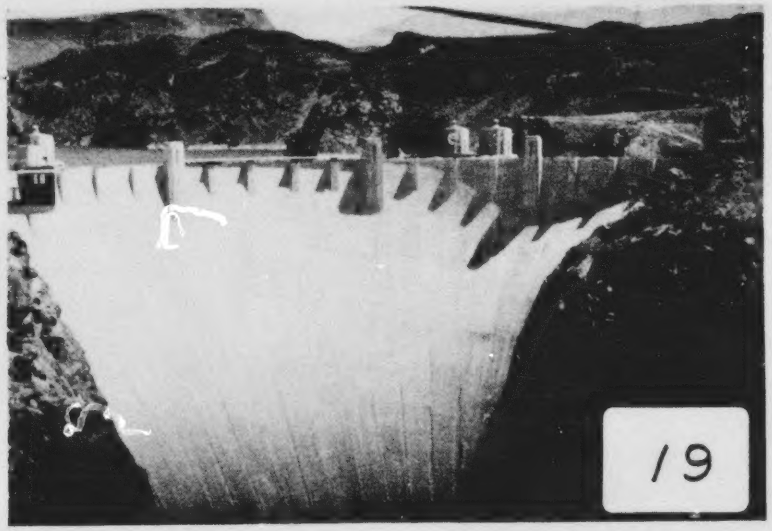
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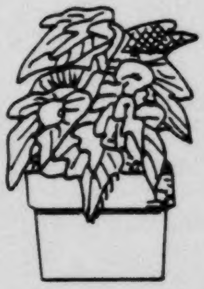
RED LIGHT, GREEN LIGHT, BLUE LIGHT

by Charlene Anderson

Look at the plants in your house and those outside your window. How many colors do you see? Trees, grass and even shrubs with colorful flowers are usually green. So many green plants grow all around us that it is hard to think of plants being any other color. But, most seaweeds are red!



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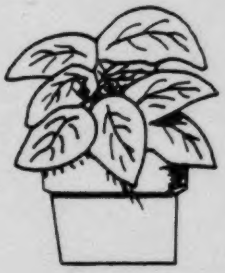


PLANT NO. 2

Red algae, or seaweeds, plants without roots, grow in water, as shallow as a few centimeters or as deep as 180 meters (about 60 feet). Many different kinds of red algae thrive in the sea. Each has its own special place, or niche, in the world.

Red algae live in all the oceans from the Arctic to the Antarctic. Some have hard, cement-like skeletons to support them. Others, the soft and slimy ones, grow on other plants. Most plants in the red algae family range in color from pink to deep red to very dark purple. Some even have green exteriors, but inside they have the red pigment, or coloring, that gives red algae its name.

Why are most seaweeds red? We have to understand the nature of light to answer that question. The white light which comes to the earth from the sun is made up of all the different colors we see. Individual colors can be separated from the white light. At sunset we see a beautiful red sky because all the other colors have been sifted out of white sunlight by the earth's atmosphere.

When light hits an object, most of the lift is absorbed, or soaked up. But some of it bounces off the object and into our eyes. Whatever color of light bounces off the object is the color we see.

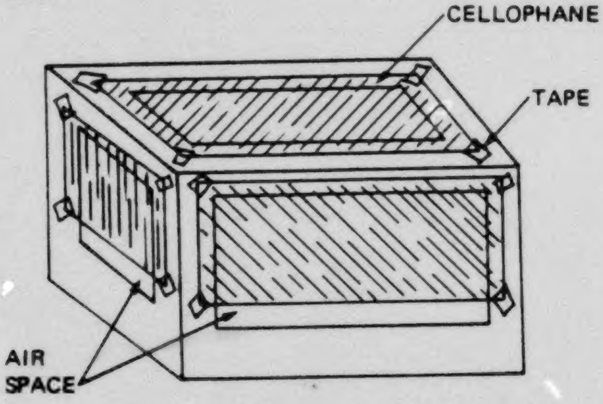
Plants on land look green because they have a green pigment, chlorophyll, in their leaves. They soak up most of the energy in sunlight. But the green light bounces off the leaves and into our eyes.

Sunlight gives plants their energy. If all light from the sun suddenly turned green most plants would die. The green light would bounce off their leaves and they couldn't absorb the energy they need.

But if the sun was green, red algae would do just fine. Because of its red pigment, red algae would absorb the green sunlight and go on living as if there were nothing strange about a green sun. For millions of years, red algae has had to live on blue-green light from the sun, since the water in which it lives absorbs most of the colors in white sunlight.

The red light that creates such beautiful sunsets disappears first as the sunlight moves into the sea water. Orange and yellow soon follow. Blue and green light are the only colors that penetrate through the water. If the plants living in the deep ocean were green, most of the sunlight reaching through the water would bounce off them. They would not get enough energy to live.

Long ago, before there were plants of any color on land, red algae adapted, or changed, from a blue-green color to red so they would live in the blue-green light of the ocean. Today, most of the seaweed in the ocean is red.



To see how colored light affects plants, you can create your own ocean-like environment with a cardboard carton and blue or green cellophane. Find a box about 30 centimeters (one foot) by 45 centimeters (one and one half feet). Cut the top off. Cut large windows in the five remaining sides of the box, leaving about five centimeters (two inches) of cardboard around the edges to frame the windows.

Cut the rectangles of blue or green cellophane for each window. Make the pieces about one inch larger than the windows they are to cover. Tape the cellophane to three sides of the window, leaving one side open so air can circulate through the box. You now have created an environment similar to the undersea world.

Now you need two small plants, one with green leaves and one with red leaves. Many kinds of coleus plants have red leaves. Place the box in a south-facing window or on the south side of your house. Put the plants inside the box.

Take good care of both plants and don't forget to water them now and then. Check them everyday for about two weeks. You may want to keep a notebook to write down your daily observations. Is there any difference in the growth rate of the plants? Which one is losing its color? Which one do you think grows best in blue or green light?

At the end of two weeks, remove the plants from the box and return them to normal sunlight. Do their colors change? Which plant is growing faster now?

RECORD SHEET

NAME ____________________

1. THE PROBLEM: ____________________

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2. YOUR PREDICTION (YOUR GUESS)

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3. OBSERVATION –
WHAT HAPPENED

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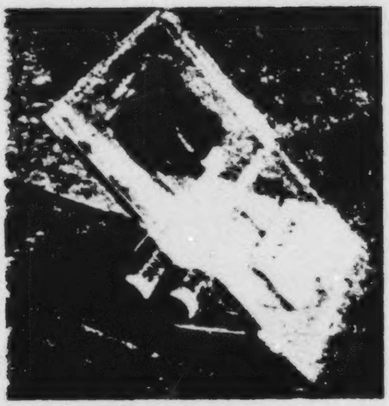
4. ARE SQUARES 3 AND 4 THE SAME ____________________

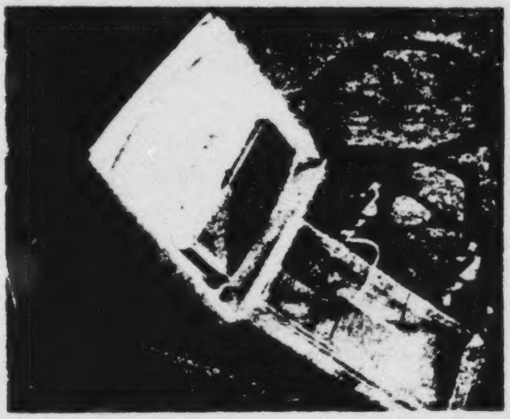
SPECIAL ENERGY TEACHING APPARATUS

SUN-OF-A-CELL: This unit is composed of a silicon photovoltaic cell (converts sunlight directly into electricity), a small electric motor (the motor is rated at 1-1/2 volts DC but runs well on the 1/2 volt from the silicon cell), and a small propellor. Besides demonstrating the direct conversion of sunlight to electricity, the device illustrates how energy can be cascaded from one form to another.

SUNSTOR: This device is based on four (4) silicon photovoltaic cells in series. Each cell is rated at approximately 0.5 volt DC at 100 milliamperes. The four cells therefore produce about 2 volt DC at the 100 milliamp current in full sunlight. This combination is ideal for charging two "AA" size nickel-cadmium rechargeable batteries in parallel (each battery is rated at 1.25 volt DC and recharges at a rate of about 50 milliamp). The extra voltage of the cells is needed to insure an energy flow into the batteries. Sunstor illustrates a "solar system" with energy storage and also can be used as a tool in the study of the connection of lifestyle and energy.

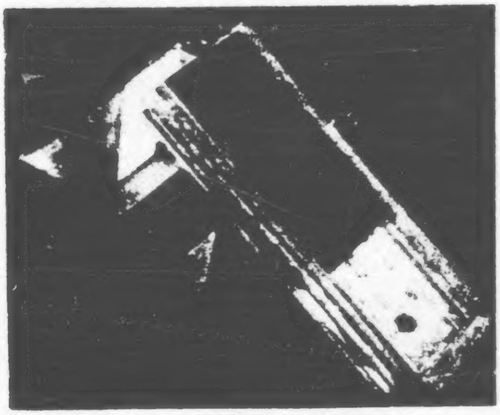


SILICON CELL AND METER: The combination of a single 0.5 volt DC, 100 milliamp silicon cell with a 100 milliamp meter makes a good simple light energy measuring device. On a bright sunny day the meter and cell combination will read full scale. In addition to a 0-100 relative energy scale, the meter may also be considered to read roughly directly in units of milliwatts/square centimeter (e.g. 100 milliwatts/cm^2 full scale)



THERMO-SIPHON HOT WATER SYSTEM: This system is composed of an 8 inch by 8 inch solar thermal collector to convert the radiation of the sunlight into heat energy and then pass this heat into water that is stored in an approximate one quart tank. The side of the solar collector is removeable so that students may see how it is made. The tank is not insulated and consequently the water only reaches temperatures of about 100°F, a safe level that feels warm but will not cause pain or burns. The devices are used in the study of solar thermal systems.

COLORTEMP THERMOMETER: The Colortemp thermometer is a dual range (Celsius and Fahrenheit) unit that has been encased in plastic. It may be used to measure air or liquid temperatures. The Colortemp has also been constructed so that it may accept colored overlay plastic see through pieces that allow temperature to be thought of in terms of "cool, warm, and hot" colors when dealing with very young students. In this case the Colortemp is used with a special worksheet that has a black and white outline of the thermometer face. It is colored by the students to match the real instrument and experiments are done by drawing in the "red" temperature line of the thermometer.



MULTI-PURPOSE CARD DECK: The deck is composed of 19 4 x 5 inch photographs (printed four to a page) that the students may cut out and mount on cardboard. The pictures cover a wide range of items that the students may see in their normal lives (e.g. a loaf of bread: car in motion; Hoover Dam; etc.). The pictures are numbered, and included with the set is an information sheet for the teacher that tells what each photo is, whether it illustrates direct or indirect use of solar energy, the main forms of energy demonstrated, and what environmental impacts it may cause.

SUNSTOR

Solar Battery Charger

WHAT MAKES THE SUNSTOR WORK?

The SunStor uses a "silicon photovoltaic" cell to generate the needed voltage and current to charge two parallel "AA" size nickle cadmium rechargeable batteries.

Silicon cells are amazing little devices. They are made by a sophisticated manufacturing process that takes very pure silicon (the basic component of rock and sand), adds slight amounts of other elements such as boron and phosphorus (this part of the technique is called "doping"), and eventually produces the wafer thin photovoltaic cell. A silicon cell will take the radiant energy (sunlight) falling on it and convert it directly into electrical energy. Depending on how the cell has been made, anywhere from 10% to 15% of the Sun's energy can be translated into electricity.

The finished silicon photo cell, like a battery, produces both voltage and current. The voltage that a silicon will produce is always about the same, approximately one-half (1/2) volt. The "AA" size nickle cadmium of nicad battery produces about one-and-one-quarter (1-1/4) volts when fully charged. The amount of current the silicon cell will develop depends on how physically big it is and on how much sunlight is falling on it.

Just as a battery has a "positive" and "negative" end, the silicon cell has a "positive" and "negative" side. The negative (-)

side of the silicon cell is the side with the lines on it; the side that faces the Sun. The back or plain side is electrically positive (+).

HOW DOES THE SUNSTOR WORK?

One may look at "voltage" as the ability or potential for current to flow. Just as water will run from a higher to a lower place, current will only flow from a higher to a lower voltage. As stated above a fully charged "AA" size nicad battery will have a voltage of about 1-1/4 volts. Consequently, to make current flow into it and recharge it will require that our little module of silicon cells produce a potential or voltage greater than this amount.

More water will flow in a creek or river that has a fast or large current. When we think of electricity, current has just about the same meaning. With water we measure current in terms of miles per hour or kilometers per hour. In the case of electricity we measure current in terms of a unit called an "ampere." The larger the current or "amperage," the more electrical energy that is flowing in our wires. Nicad batteries of the "AA" size should be recharged at a rate of about 50 milliamperes (a milliampere is one one-thousandth of an ampere).

The reason for this restriction can again be thought of in terms of the analogy with water. Imagine battery size as the size of a river or creek. If too much water flows in a river, it will flood over its banks and cause damage to the surrounding country side. The "AA" battery can take a certain current flow into it. If we attempt to charge the "AA" battery with a much higher amperage than 50 milliamperes, the battery will have difficulty in keeping the electrical energy. This energy will then "flood over the banks," causing the battery to heat up and get warm. If the battery is allowed to get too hot for too long a period of time, it will be permanently damaged.

In the SunStor there are four small silicon cells put in series. That is, the positive side of one cell is connected to the negative side of the next cell, etc. In this way, the voltage of one cell builds on the others to produce a total voltage of about two (2) volts or greater. The side of the silicon cells used is such that our little module of photovoltaic cells will produce a current of about 100 milliamperes in bright sunlight. Consequently, we have a little solar system that is capable of charging two "AA" size nickle cadmium batteries that are in parallel (i.e. side by side).

HOW DO I USE THE SUNSTOR SOLAR BATTERY CHARGER?

1. Charging Batteries

   When the batteries are inserted into the battery holder, make sure that the positive (+) terminal of the batteries is on the end of the holder that is painted red. The negative (-) end of the batteries should be at the end of the battery holder painted blue. Batteries that are discharged should be brought back to a state of full charge in about two days of exposure to bright sunlight. If you do not want to use your batteries right away, it will not hurt them to leave them charging in the sunlight for several days. The batteries will even receive a small rate of charge if the SunStor is left in a brightly lit room. If you put your SunStor away in a drawer on other dark place, it is recommended that the batteries be removed from the holder. In darkness the batteries will discharge back through the silicon cells at a very low rate (about 2 milliamperes), but after many days this could lower the charge on your batteries. One final point - when you use the SunStor outside, make sure the little solar module is aimed at the Sun or in a generally Southern direction.

2. A State of the Sun Light

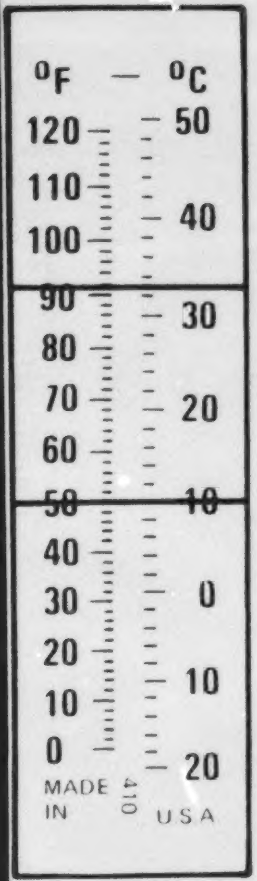
The SunStor can be used in conjunction with a small light bulb, the type used as panel lights with electronic equipment, to make a crude but very simple device to visually determine the amount of Sun present outdoors when you are in a room or area with no windows or view of the outside. Put the SunStor in some accessible but secure location outside in the sunlight. Make sure that you do not forget to remove the batteries from the battery holder. Otherwise, the small light bulb will burn brightly regardless of how cloudy it may be.

Using "clip" leads, run two wires, one from the positive end of the battery holder and one from the negative end, into the room or location you will be in. Use a type 48 or type 49 panel lamp with the appropriate base, and connect the wires coming from the SunStor to the lugs on the bulb base. On a very sunny day the lamp will burn brightly. When clouds pass in front of the Sun or the day is overcast, the bulb will dim or even go out completely. After a bit of practice, it will be possible to maintain "contact with the real world outside" when you are inside a room without windows.

3. Experiments in Energy Life-Style

Over a day one can collect a certain amount of energy. This energy is stored in the batteries at a slow rate. When the batteries are used the energy drawn from them may be done much more quickly than it was put into them. It therefore becomes an interesting study in how we use energy in our lives to match up some tasks that use energy with how we get energy, e.g., how long can we use a flashlight in which the batteries were charged for one day in the Sun. Can we invent a "life-style" using the flashlight that will allow us to do some necessary taks throughout the day and still stay within our energy budget? These tasks might be using the flashlight to read a thermometer in a dark area a certain number of times per day or use it at night for a certain period of time. If one does not apply energy conservation techniques, he may find he does not have the battery energy available when he needs it.

TEMPERATURE RECORD SHEET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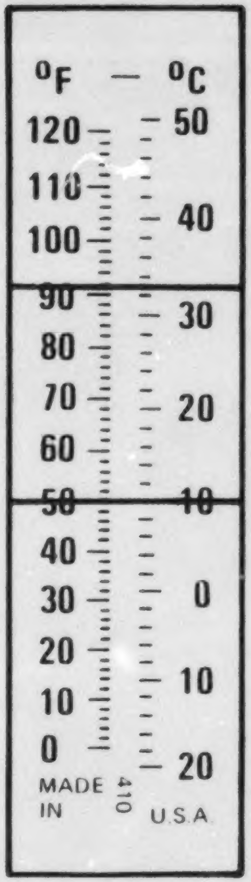
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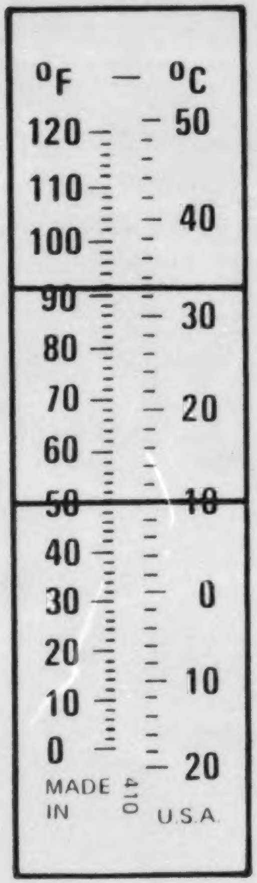
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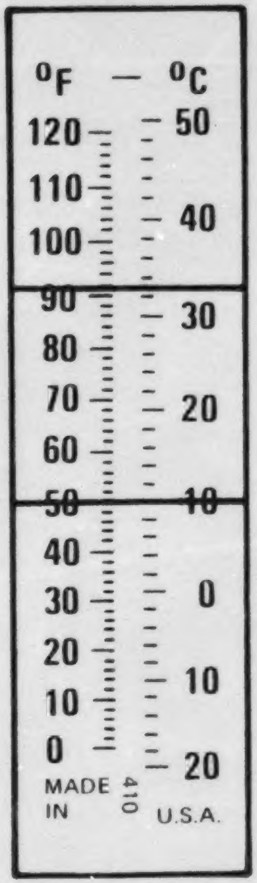
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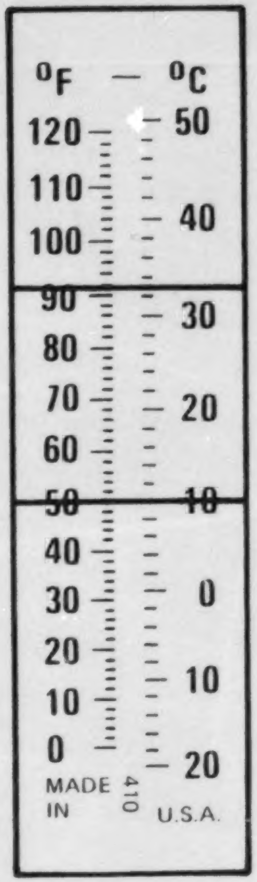
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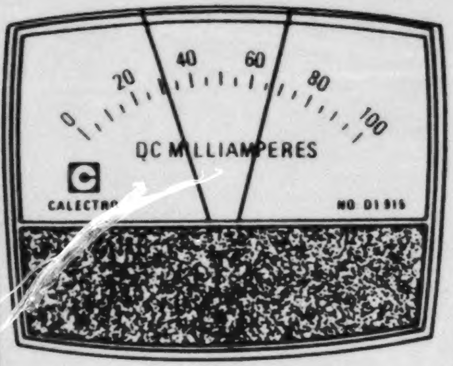
METER RECORD SHEET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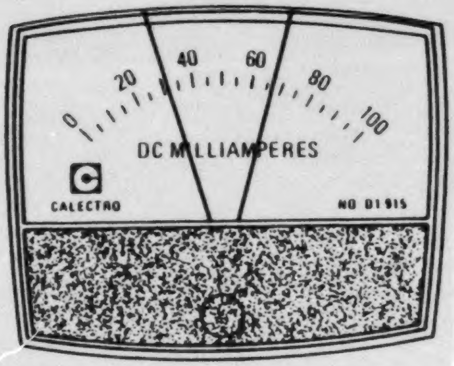
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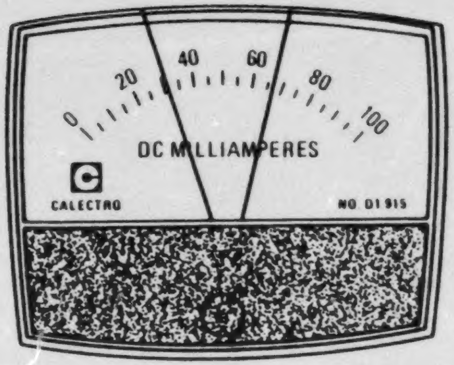
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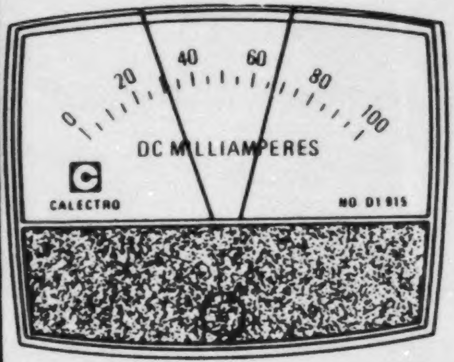
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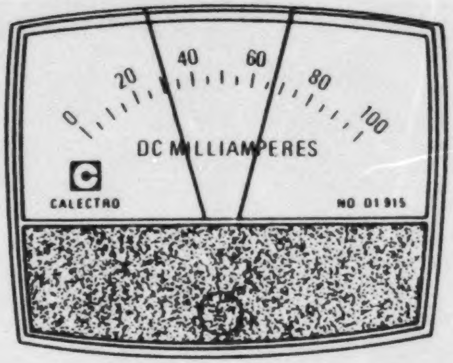
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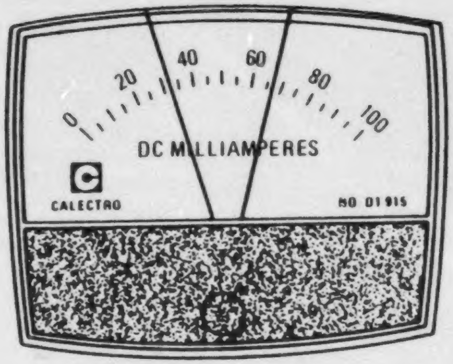
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A TEN CENT SOLAR HOT DOG COOKER

BASIC MATERIALS YOU WILL NEED

1. Two pieces of heavy cardboard (like the side of a cardboard carton). The first piece must be at least ten inches square and the second smaller piece must be at least four inches by five inches.

2. A piece of light posterboard eight inches wide and sixteen inches long.

3. Twelve inch wide aluminum foil (you will use about 32 inches of the material).

4. Some masking tape.

5. Nine inch long sticks about 1/16 inch in diameter. You may also use lengths of heavy wire. (You may find at your local grocery store in the international food section small bamboo sticks imported from Japan to make shish kebobs. These are very inexpensive and will do the job very well.)

6. Four one inch long spreading brass brads.

NOW LET'S MAKE IT

____ 1. Using a large compass or a string and pencil, lay out a ten inch diameter circle on the larger piece of heavy cardboard. Cut out this circle using a large scissors or a sharp knife.

____ 2. Draw a straight line (line "1") through the center pinhole in the cardboard, (i.e., a line along the diameter of the circle).

____ 3. Mark off points at 2-1/2 inches (hole "a") and 3-1/4 inches (holes "b") on either side of the centerpoint along the straight line you just have drawn.

____ 4. Draw a straight line (line #2) 3/4 inch on one side of the straight line through the center.

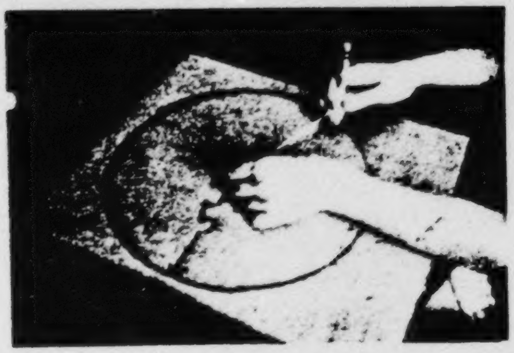
____ 5. Draw a line that goes at right angles to the lines you have drawn and through the center hole (line #3).

____ 6. Mark off holes that are 4-1/4 inch (holes "c") on line #2 from line #3.

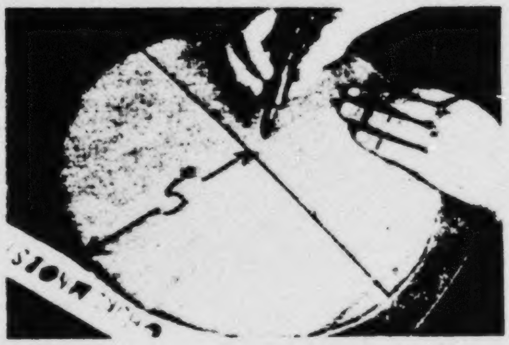
____ 7. Using an ice pick or other sharp instrument, punch out the holes "a," "b," and "c".

____ 8. Using a sharp knife or razor blade, cut along line #3 so that the cardboard circle is cut in half.

____ 9. Put the cardboard semicircles to one side now and get your piece of posterboard. (It should already be eight inches wide and sixteen inches long.)



STEP 1



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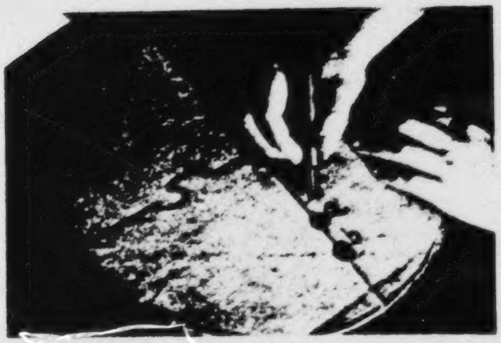
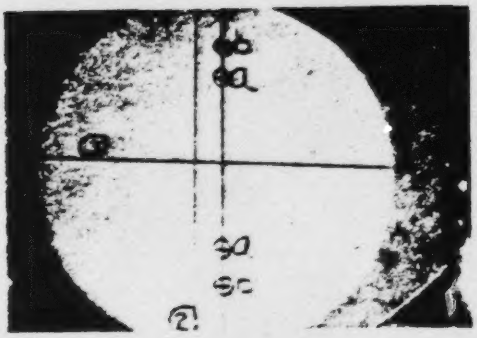


STEP 3

STEP 4



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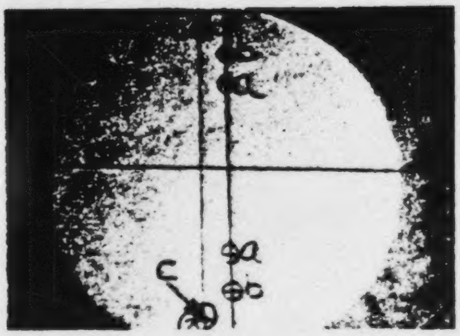


STEP 6

____ 10. Take a piece of aluminum foil that is about 18 inches long (and, of course, twelve inches wide).

____ 11. Lay the shiny side of the foil down on the table and put the piece of posterboard on top of it — center the board so that there is roughly an equal amount of foil sticking out on all sides.

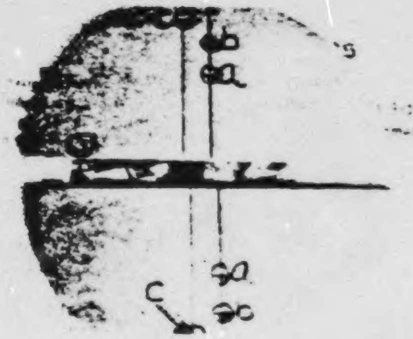
____ 12. Fold the aluminum foil over the posterboard so that the side of the board facing down on the table will be foil covered. Put a few pieces of masking tape at the corners and along the sides to hold the foil securely in place. Put the foil-covered posterboard to one side for a moment.

____ 13. Take the two half circles of heavy cardboard. These will be the sides of the hot dog cooker. Hold them up for a moment so that you can see how the holes line up.

____ 14. Mark the sides of the half circles that are on the outsides away from where the hot dog will be, with an "0" (for the "outside," of course!).

____ 15. Mark the other sides with an "I" (you guessed it — for "inside"!).

____ 16. Get two more pieces of aluminum foils that are about seven inches long (of course, again, twelve inches wide). Lay one of the pieces down on the table, shiny side down, as you did with the larger piece of foil.



STEPS 7,8

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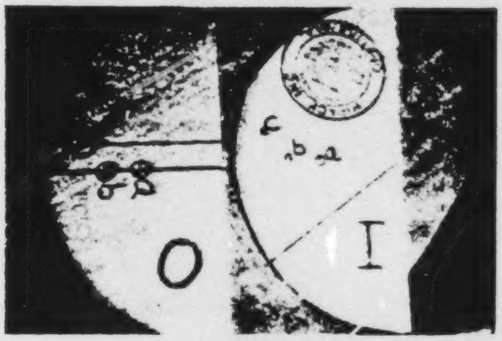
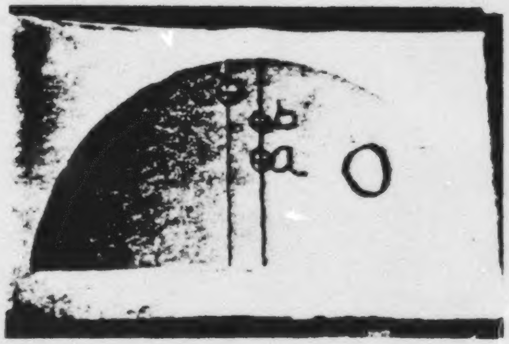
STEP 12



STEPS 13,14,15



STEPS 16,17

STEPS 18,19,20

____ 17. Put one of the half circles with the "I" (inside) side down onto the foil (the "O" side will be up). Again, center the piece of cardboard on the foil.

____ 18. Fold the foil over the cardboard and tape the foil to hold it.

____ 19. Make sure you find the "a," "b," and "c" holes and poke them through the foil.

____ 20. Do the same thing with the other half circle of cardboard so that it is also foil covered on the inside surface.

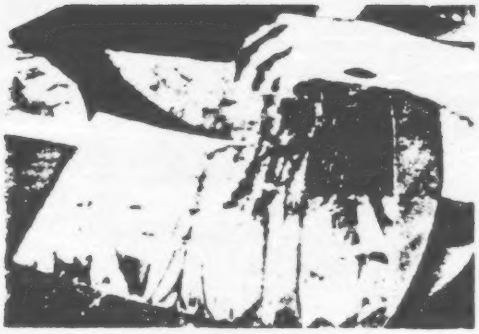
Now, we will assemble the back and sides of the cooker.

____ 21. Lay the aluminum-covered posterboard down on the table with the aluminum-covered side up.

____ 22. Take one of the aluminum-covered half circles. Hold it so that the aluminum-covered side faces in towards the aluminum cover on the posterboard, and also so that the outside edge of the half circle (where it was cut along line 3) lines up with the edge of the posterboard.

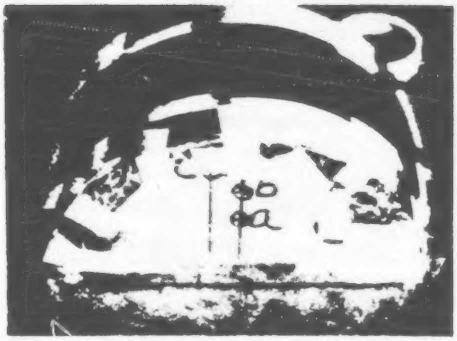
____ 23. Put a piece of tape from the posterboard to the cardboard so that the cardboard half circle stands up on the aluminum-covered posterboard.

____ 24. Now roll the aluminum-covered half circle along the edge of the aluminum-covered posterboard, putting a piece of tape every two or so inches as you go. Make sure there is a snug fit between the aluminum half circle side and the foil-covered back posterboard.



STEPS 21,22,23

STEP 24



STEP 25

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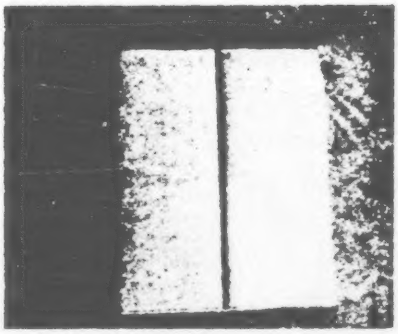


STEP 28

____ 25. Continue until the half circle (with the aluminum foil on the inside) is attached to the aluminum foil-covered posterboard. (This will make one end of a trough.)

____ 26. Now attach the other foil-covered cardboard half circle, with the aluminum-covered side facing in, to complete the trough. Use a similar technique as you did with the other piece of cardboard using tape every two or so inches.

____ 27. Put the trough to one side.

We are almost done now!

____ 28. Take the small piece of heavy cardboard (four inches by five inches) and draw a line (line 4) down the center along the five-inch length.

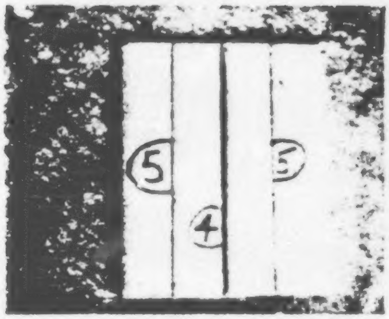
____ 29. Draw a straight line one inch on each side of line 4 (lines #5).

____ 30. Mark off points one-half inch and 1-5/8 inches along line 5 from one end of the cardboard (holes "d").

____ 31. Punch out holes "d" using an ice pick or sharp instrument.

____ 32. Using a sharp knife or razor blade, cut along line 4 so that you have two pieces of cardboard, each two by five inches.

____ 33. Put two brass brads from the inside of the trough through holes "b" and "c", and through holes "d" on the two-inch by five-inch piece of cardboard. Spread the brad so that the rectangular piece of cardboard is securely attached to one side of the cooker.



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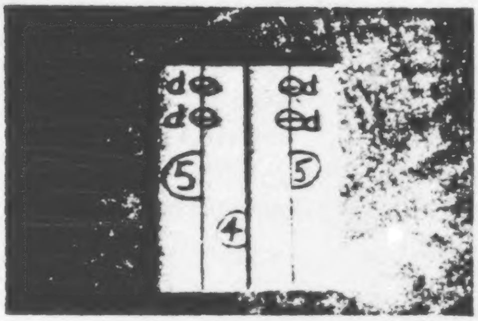

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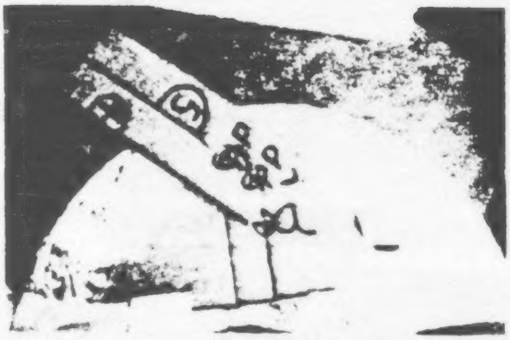
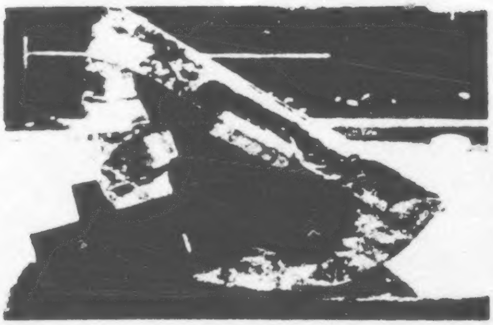


STEPS 31,32,33,34

STEPS 35,36,37



STEP 38

STEP 39

____ 34. Do the same thing on the other side of the cooker with the remaining piece of two-inch by five-inch cardboard.

These pieces of cardboard act as legs to prevent the hot dog cooker from just rolling around on the table.

NOW, YOU ARE READY TO START COOKING!

____ 35. Slide the stick from the outside in through one of the "a" holes.

____ 36. Hold the hot dog so that as you slide the stick further in through the "a" hole, you also put the stick through the length of the hot dog.

____ 37. Continue until the stick is completely through the hot dog. Then, put the stick about one-fourth inch through the other "a" hole so that the stick and hot dog are supported at both ends. Center the hot dog on the stick.

____ 38. In summer, stand the cooker so that the opening looks more upward and, if winter, turn the cooker over so that the opening faces more downward.

____ 39. Aim the hot dog cooker toward the sun. It will take about 45 minutes to one hour, and then ... HAPPY HOT DOG EATING! Note: You can shorten your cooking time by stretching a piece of clinging plastic wrap over the whole front of the cooker after the hot dog is on the stick. This will keep the hot dog from cooling down as the wind blows over it. If you or your class come up with any special recipes using

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the cooker, please send a copy to the author so that he can let others know about it, giving proper credit. Thank you. Enjoy solar cooking.

NATIONAL SOLAR HEATING AND COOLING INFORMATION CENTER

P. O. BOX 1607
ROCKVILLE, MD 20850

CALL TOLL FREE (800) 523-2929
IN PENNSYLVANIA CALL (800) 462-4983

READING LIST FOR SOLAR ENERGY

NON-TECHNICAL

THE BUY WISE GUIDE TO SOLAR HEAT...F. Hickok; Hour House, P. O. Box 40082, St. Petersburg FL 33743, 1976, 121 pp, $9.00. The consumer's guide to solar heating and cooling; what to buy, what to do, what to beware of.

THE COMING AGE OF SOLAR ENERGY...D. S. Halacy, Jr.; Harper & Row, Inc., New York NY 10022, 1973, 231 pp, $7.95. Interesting for its historical treatment of solar energy.

DIRECT USE OF THE SUN'S ENERGY...F. Daniels; Ballantine Books, Inc., Westminster MD 21157, 1964, 271 pp, $1.95. Covers all aspects of solar energy research and application; provides a general introduction to the subject.

HOMEOWNER'S GUIDE TO SOLAR HEATING AND COOLING...W. M. Foster; Tab Books, Blue Ridge Summit PA 17214, 1976, 196 pp, $4.95. Covers the basics of solar heating along with practical advice for consumers.

HOW TO BUILD A SOLAR HEATER...T. Lucas; Ward Ritchie Press, Pasadena CA 91103, 1975, 236 pp, $4.95. Guide to building and buying solar collectors, water heaters and pool heaters; includes list of manufacturers, bibliography, and glossary.

SOLAR HOMES AND SUN HEATING...G. Daniels; Harper & Row, Inc., New York NY 10022, 1976, 178 pp, $8.95. Practical guide on solar heating for the layman; presents a non-technical description of basic principles, existing systems and techniques for construction and installation.

YOUR HOME'S SOLAR POTENTIAL...I. Spetgang and M. Wells; Edmund Scientific Co., Barrington NJ 08007, 1976, 60 pp, $9.95. Contains do-it-yourself home survey to evaluate existing energy utilization and to determine solar savings potential.

TECHNICAL

APPLICATIONS OF SOLAR ENERGY FOR HEATING AND COOLING OF BUILDINGS...R. C. Jordan and B. Y. H. Liu (eds); ASHRAE (Sales Dept), 345 E. 47th St., New York NY 10017, 1977, 206 pp, $9.00. Compilation of technical articles on the assessment, components, performance, and application of solar energy for heating and cooling; includes references, charts and index.

APPLIED SOLAR ENERGY: AN INTRODUCTION...A. B. Meinel and M. P. Meinel; Addison-Wesley Publishing Co., Reading MA 01867, 1976, 651 pp, $17.95. Basic textbook introduction to the theory of solar energy; intended for college seniors or graduate students.

SOLAR ENERGY THERMAL PROCESSES...J. A. Duffie and W. A. Beckman; John Wiley & Sons, Inc., New York NY 10016, 1974, 386 pp, $18.00. How to understand and predict the performance of solar collectors and solar photothermal systems for heating and cooling buildings and for heating water and air; comprehensive and coherent treatment for professionals, and especially for engineers.

SOLAR HEATING AND COOLING: ENGINEERING, PRACTICAL DESIGN, AND ECONOMICS...J. F. Kreider and F. Kreith; McGraw-Hill Book Co., New York NY 10036, 1975, 342 pp, $24.75. Designed as a how-to handbook with emphasis on economically feasible heating and cooling systems; contains considerable technical detail and extensive tables of reference data.

SOLAR HEATING SYSTEMS DESIGN MANUAL...International Telephone & Telegraph Corporation, Fluid Handling Division, 4711 Golf Rd., Skokie IL 60076, 1976, c100 pp, $2.50. Brings together technical data, procedures, and designs necessary to install a solar hydronic heating system; based on system installed at ITT's training facility in Morton Grove.

OPERATED BY THE FRANKLIN INSTITUTE RESEARCH LABORATORIES FOR THE ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION AND THE DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT. THE NATIONAL CENTER AND THE ABOVE ORGANIZATIONS DO NOT ENDORSE, RECOMMEND OR ATTEST TO THE QUALITY OR CAPABILITY OF ANY PRODUCTS OR SERVICES OF COMPANIES OR INDIVIDUALS.

ARCHITECTURAL

DESIGNING AND BUILDING A SOLAR HOUSE...D. Watson; Garden Way Publishing, Charlotte VT 05445, 1977, 240 pp, $8.95. Practical clearly-written book which covers all aspects of solar house design, including siting, equipment, different types of systems, and costs.

SOLAR ENERGY AND BUILDING...S. V. Szokolay; John Wiley & Sons, New York NY 10016, 1975, 148 pp, $18.50. Provides a conceptual understanding of the problems and solutions of solar energy; contains an illustrated architectural review of "solar houses" including plans and performance data.

SOLAR ENERGY: FUNDAMENTALS IN BUILDING DESIGN...B. Anderson; McGraw Hill Book Co., New York NY 10036, 1977, 374 pp, $21.50. More technical version of the Solar Home Book; designed for architects and building professionals.

SOLAR HEATED BUILDINGS: A BRIEF SURVEY (13th edition)...W. A. Shurcliff; 19 Appleton St., Cambridge MA 02138, 1977, 306 pp, $12.00 prepaid. Contains descriptions of 319 buildings which are partially or fully solar heated; includes buildings that did exist, do exist or are expected to exist very soon. Permits comparison of characteristics and performances of a wide variety of solar heated buildings.

SOLAR HOME BOOK...B. Anderson and M. Riordan: Cheshire Books, Harrisville NH 03450, 1976, 297 pp, $7.50. Covers various aspects of solar home heating including architectural, direct and indirect systems, do-it-yourself solar water heating, retrofitting and social and cultural implications.

SOLAR PRIMER ONE...B. Carlson; SOLARC, Whittier CA 90607, 1975, 101 pp, $8.75. Written by architects; presents basic solar applications and building design with discussions of collectors, structure, heat transfer, storage and total heating and cooling systems.

SUN-EARTH...R. L. Crowther, et al; Crowther/Solar Group, Denver CO 80206, 1976, 232 pp, $12.95. A survey of architecture and its relation to the natural environment; presents cost effective concepts for use of free natural energy sources in homes and other buildings.

GENERAL ENERGY

ENERGY FOR SURVIVAL...W. Clark; Doubleday & Co., Inc., New York NY 11530, 1974, 652 pp, $4.95. Energy sources in the past, present, and prospects for the future; major section on solar energy; extensive information sources and guide to sources.

ENERGY BOOK # 1 and # 2: NATURAL SOURCES AND BACKYARD APPLICATIONS...J. Prenis (ed); Running Press, Philadelphia PA 19103, 1975, 112 pp, $4.00. (BOOK # 2 - 1977, 125 pp, $5.00.) Review of possible alternative sources of energy; short descriptions of different ideas and disigns.

HOME ENERGY HOW-TO...A. J. Hand; Harper & Row, New York NY 10022, 1977, 258 pp, $9.95. Complete guide to saving and producing home energy.

HOMEOWNERS GUIDE TO SAVING ENERGY...B. L. Price and J. T. Price; Tab Books, Blue Ridge Summit PA 18214, 1976, 288 pp, $5.95. How to save money on home heating, cooling, appliance and electricity costs.

LOW-COST ENERGY-EFFICIENT SHELTER FOR THE OWNER AND BUILDER...E. Eccli (ed); Rodale Press, Inc., Emmaus PA 18049, 1976, 408 pp, $5.95. Covers the basics involved in owning and building an energy-efficient home; includes solar applications.

OTHER HOMES AND GARBAGE: DESIGN FOR SELF-SUFFICIENT LIVING...J. Lecki et al; Chas. Scribner's Sons, New York NY 10017, 1975, 302 pp, $9.95. Practical approach for constructing solar panels and ovens, as well as windmills, and water wheels; emphasizes renewable energy sources.

THE POVERTY OF POWER: ENERGY AND THE ECONOMIC CRISIS...B. Commoner; A. Knopf, New York NY 10022, 1974, 320 pp, $8.95. The energy crisis as seen by an environmentalist; covers government and industrial opposition to alternative energy sources and recommendations for the future.

DIRECTORIES

INFORMAL DIRECTORY OF THE ORGANIZATIONS AND PEOPLE INVOLVED IN THE SOLAR HEATING OF BUILDINGS (3rd edition)...W. A. Shurcliff; 19 Appleton St., Cambridge MA 02138, 1976, 178 pp, $9.00. Selective coverage of institutions and individuals involved in all aspects of solar heating of buildings; main emphasis is on U.S., but some foreign groups are included.

SOLAR DIRECTORY...C. Pesko (ed); Ann Arbor Science Publishers, Inc., Ann Arbor MI 48106, 1975, $20.00. An overall guide to solar energy activity, U. S. and foreign; covers information services, manufacturers, distributors, research activities, projects and includes a bibliography.

SOLAR ENERGY AND RESEARCH DIRECTORY...Ann Arbor Science Publishers, Inc., Ann Arbor MI 48106, 1977, $22.50. Comprehensive directory of all types of companies involved in various aspects of solar energy technology.

SOLAR ENERGY SOURCE BOOK...C. W. Martz (ed); Solar Energy Institute of America, P. O. Box 9352, Washington DC 20005, 1977, 712 pp, $12.00. Loose-leaf guide to manufacturers and organizations; periodic updates provided to members.

SOLAR UPDATE...Environment Information Center, 124 E. 39th St., New York NY 10016, 1977, $25.00. Guide to information sources in solar energy.

SOLAR UTILIZATIONS NEWS. Alternate Energy Institute, P. O. Box 3100, Estes Park CO 80517, Monthly, $8.00/yr. Covers regional developments, publications and meetings.

SOLAR INDUSTRY INDEX...Solar Energy Industries Association, 1001 Connecticut Ave., NW, Ste. 632, Washington DC 20036, 1977, 381 pp, $8.00 + $2.00 Mailing. Comprehensive guide to manufacturers and service organizations; also includes chapter on operations and economics of solar systems.

PERIODICALS

ALTERNATIVE SOURCES OF ENERGY. Alternate Sources of Energy, Inc., Route 2, Box 90A, Milaca MN 56353, Quarterly, $10.00/yr. Combination of articles, columns and features on many aspects of energy alternatives; serves as a clearinghouse for exchange of ideas and technologies.

THE MOTHER EARTH NEWS. The Mother Earth News, Inc., 105 Stoney Mountain Road, Hendersonville NC 28739, Bi-monthly, $10.00/yr. Down-to-earth descriptions of peoples' experiences with alternative lifestyles, ecology and energy; source for what is happening in energy at the grass roots level.

SOLAR AGE. Solar Vision, Inc., 200 E. Main St., Port Jervis NY 12771, Monthly, $20.00/yr. Brief articles on developments in solar energy applications, with emphasis on solar heating and cooling.

SOLAR ENERGY. Pergamon Press, Inc., Maxwell House, Fairview Park, Elmsford NY 10523, Bi-monthly, $100.00/yr. (Included with membership in International Solar Energy Society - $20.00) Contains scientific and engineering papers on all aspects of solar energy and technology, theory, and applications.

SOLAR ENERGY DIGEST. CWO-4 W. B. Edmondson, P. O. Box 17776, San Diego CA 92117, Monthly, $28.50. Concise summaries of solar energy developments, on-going research and publications, both U. S. and foreign.

SOLAR ENERGY INTELLIGENCE REPORT. Business Publishers, Inc., P. O. Box 1067, Silver Spring MD 20910, Bi-weekly, $90.00. Covers the Washington beat in solar energy; also new developments, markets, meetings.

SOLAR ENGINEERING. Solar Engineering Publishers, Inc., 8435 N. Stemmons Freeway, Suite 880, Dallas TX 75247, Monthly, $15.00/yr. Short(1-3 pages) descriptions of activities and developments in the field of solar energy, particularly in the private sector and in the U.S.

SOLAR HEATING & COOLING. Gordon Publications, P. O. Box 2126-R, Morristown NJ 07960, Bi-monthly, $6.00/yr. Short articles on solar heating and cooling issues, developments and equipment. Oriented to builders, developers, and manufacturers.

GOVERNMENT PUBLICATIONS

BUYING SOLAR...Federal Energy Administration; Stock No. 041-018-00120-4, GPO, June 1976, 71 pp, $1.85. Guide to factors a homeowner should consider when buying solar systems.

A DESCRIPTIVE SUMMARY OF H.U.D. SOLAR RESIDENTIAL DEMONSTRATIONS, CYCLE 2, Fall 1976... AIA Research Corporation; Stock No. 023-000-00389-9, GPO, 1977, 103 pp, $2.30. Describes solar grant projects selected from the second cycle grant applications in the HUD solar heating and cooling demonstration program; includes drawings of buildings and solar systems.

ERDA'S PACIFIC REGIONAL SOLAR HEATING HANDBOOK...Los Alamos Scientific Laboratory; Stock No. 060-000-0024-7, GPO, Nov. 1976, 108 pp, $3.25. Guide for engineers, architects, and individuals familiar with heating and ventilating applications who wish to design a solar heating system for buildings in the Pacific Coast Region; basic concepts are useful in other regions.

HOME MORTGAGE LENDING AND SOLAR ENERGY...D. Barrett et al; Stock No. 023-000-00387-2, GPO, 1977, 31 pp, $1.40. Results of a series of interviews with mortgage loan officers at financial institutions in New England; main focus was on mortgage financing for new housing with solar energy space heating systems.

H.U.D. INTERMEDIATE MINIMUM PROPERTY STANDARDS SUPPLEMENT: SOLAR HEATING AND DOMESTIC HOT WATER SYSTEMS...Order No. 4930-2, GPO, 1977, $12.00 (includes updates). Contains solar requirements and standards applicable to one and two family dwellings, multifamily housing, and nursing homes and intermediate care facilities.

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING OF BUILDINGS...Energy Research and Development Administration; Stock No. 060-000-00043-3, GPO, 1976, 84 pp, $1.55. Reflects results of continuing assessment of the Program during 1976.

NATIONAL PROGRAM FOR SOLAR HEATING AND COOLING OF BUILDINGS: PROJECT DATA SUMMARIES, Vol. 1 - COMMERCIAL AND RESIDENTIAL DEMONSTRATIONS, Stock No. 060-000-00012-3, 1976, 163 pp, $2.35; Vol. 2 - DEMONSTRATION SUPPORT, Stock No. 060-000-00042-5, 1976, 61 pp, $1.25; Vol. 3 - RESEARCH AND DEVELOPMENT, Stock No. 060-000-00018-2, 1976, 99 pp, $1.90...Systems Consultants, Inc.; GPO, 1976. Brief abstracts of projects funded by ERDA and conducted under the National Program for Solar Heating and Cooling of Buildings through July 1976. Vol. 2 reports on development support for the demonstration program and Vol. 3 describes all research and development projects in the areas of collectors, thermal energy storage, solar heat pumps, solar cooling systems and controls.

SOLAR DWELLING DESIGN CONCEPTS...AIA Research Corporation; Stock No. 023-000-00334-1, GPO, May 1976, 136 pp, $2.30. Discusses all facets of the design and siting of housing intended to be heated by the sun; also includes discussion of the impact of solar energy utilization on traditional dwelling design.

SOLAR ENERGY IN AMERICA'S FUTURE: A PRELIMINARY ASSESSMENT...Energy Research and Development Administration; Stock No. 060-000-00051-4, GPO, March 1977, 104 pp, $2.00. Documents a Stanford Research Institute study of the potential roles that solar energy technologies could have for meeting U.S. energy needs over the next 45 years.

SOLAR HEATING AND COOLING DEMONSTRATION: A DESCRIPTIVE SUMMARY OF HUD SOLAR RESIDENTIAL DEMONSTRATIONS, CYCLE 1...AIA Research Corporation; Stock No. 023-000-00338-4, GPO, 1976, 59 pp, $1.15. Project summaries of 53 projects in the first cycle of residential demonstration awards. Each description includes background and climatic data, a brief discussion of the dwelling's physical characteristics and energy conservation features, and information on the components of the solar energy system.

The publications on this page are available from GPO. They can be obtained by writing: Superintendent of Documents, Government Printing Office, Washington, DC 20402. The other materials are NOT available through the National Solar Heating and Cooling Information Center. They can be obtained by contacting the publishers, bookstores or local libraries.

5th edition
7/29/77

GPO 919-099